





UNIVERSITÉ  
**YORK**  
UNIVERSITY

---

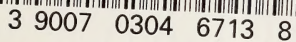
**LIBRARIES**

---





Digitized by the Internet Archive  
in 2014

[illegible]



# THE POLAR REGIONS

## METHUEN'S GEOGRAPHICAL SERIES

UNIFORM WITH THIS VOLUME

**NORTH AMERICA :** An Historical, Economic, and Regional Geography. By LI. Rodwell Jones, B.Sc., Professor of Geography in the University of London, and P. W. Bryan, Ph.D., Head of the Department of Commerce at University College, Leicester. With 104 Maps and Diagrams.

**SOUTH AMERICA :** An Economic and Regional Geography. With an Historical Chapter. By E. W. Shanahan, M.A., D.Sc. Econ., of the London School of Economics. With 50 Maps and Diagrams.

**AFRICA :** An Economic and Regional Geography. By B. Hosgood, B.A., Reader in Geography at Bedford College for Women, University of London.

*Other Volumes in preparation.*

# THE POLAR REGIONS

A PHYSICAL AND ECONOMIC  
GEOGRAPHY OF THE ARCTIC  
AND ANTARCTIC

BY

R. N. RUDMOSE BROWN

D.Sc. (Aberdeen)

UNIVERSITY OF SHEFFIELD

AUTHOR OF "SPITSBERGEN" AND "A NATURALIST AT THE POLES"

WITH 23 MAPS



METHUEN & CO. LTD.  
36 ESSEX STREET W.C.  
LONDON

587  
B7

*First Published in 1927*

PRINTED IN GREAT BRITAIN

## PREFACE

THE results of the work of polar expeditions are scattered in many scientific journals and series of collected papers. Only the popular narratives are as a rule well known and they dwell largely on the adventurous side of the expeditions. Since the main features of the distribution of land and water in high latitudes became known, the work of exploration has been focussed more and more on specific problems. New methods of exploration and greater attention to scientific work are robbing polar exploration of its more sensational appeal, but are adding greatly to its real value.

The present volume aims to give a collected account of the actual state of knowledge of north and south polar regions with indications of the many problems that still await solution. The study is not confined to physical and biological geography, but deals at some length with the growing commercial and political penetration of polar regions and the colonization of land in high latitudes.

Among the mass of writings on polar subjects in the journals of a dozen or more countries some papers of importance may have been overlooked, and it has proved impossible to cite by name every authority whose work has been consulted. I hope, however, that over twenty-five years' study of polar regions has enabled me to keep in touch with all the important aspects of exploration which have any general geographical bearing, even if limitations of space have necessitated the brief treatment of some parts of the subject. I can at least claim that wide personal experience of both Arctic and Antarctic regions has given me one essential qualification for the work.

Dr. H. R. Mill has kindly read in proof the Antarctic chapters and some other parts of the book and I owe to him

several valuable suggestions. For any errors I am alone responsible.

Acknowledgments for the use of maps are due to Messrs. Benn Bros. for Figure 15 which appeared originally in "Discovery" and to the Oxford University Press whose Oxford Outline Maps, edited by A. J. Herbertson, form the base of several sketch maps. I am indebted to one of my students, Miss N. Ward, for much help in preparing the sketch maps.

R. N. RUDMOSE BROWN

JANUARY, 1927

# CONTENTS

CHAP.	PAGE
PREFACE . . . . .	v
- I POLAR REGIONS: THEIR EXTENT . . . . .	1
- II A SKETCH OF ARCTIC EXPLORATION . . . . .	7
III A SKETCH OF ANTARCTIC EXPLORATION . . . . .	21
- IV POLAR CLIMATES . . . . .	33 ✓
- V OTHER ATMOSPHERIC PHENOMENA . . . . .	51
- VI SEA-ICE AND ITS NATURAL HISTORY . . . . .	56
- VII THE ARCTIC OCEAN: BASIN AND COASTS . . . . .	64
- VIII ARCTIC CURRENTS AND ICE . . . . .	72
IX THE ANTARCTIC CONTINENT . . . . .	83
X THE ANTARCTIC OCEAN: CURRENTS AND ICE . . . . .	93
- XI ICE-SHEETS AND GLACIERS . . . . .	99
- XII POLAR VEGETATION . . . . .	112
- XIII ARCTIC ANIMAL LIFE . . . . .	126
XIV ANTARCTIC ANIMAL LIFE . . . . .	138
- XV THE ESKIMO . . . . .	146
- XVI WHALING: NORTH AND SOUTH . . . . .	157
- XVII POLITICAL GEOGRAPHY . . . . .	167
- XVIII TRADE ROUTES . . . . .	180
- XIX COLONIZATION: GREENLAND AND NOVAYA ZEMLYA . . . . .	193
XX COLONIZATION: SPITSBERGEN . . . . .	203
- XXI COLONIZATION: THE CANADIAN ARCHIPELAGO . . . . .	212
- XXII HYGIENE . . . . .	218
BIBLIOGRAPHICAL APPENDIX . . . . .	225
INDEX . . . . .	237



# LIST OF MAPS

## IN TEXT

	PAGE
1. ARCTIC REGIONS: LIMIT OF TREES AND PACK-ICE . . .	3
2. ARCTIC REGIONS: APPROXIMATE ISOTHERMS IN JANUARY .	34
3. ANTARCTIC REGIONS: APPROXIMATE ISOTHERMS IN JULY .	36
4. ARCTIC REGIONS: APPROXIMATE ISOTHERMS IN JULY .	37
5. ANTARCTIC REGIONS: APPROXIMATE ISOTHERMS IN JANUARY	38
6. AREAS OF AURORAL FREQUENCY IN THE NORTHERN HEMI- SPHERE . . . . .	53
7. ARCTIC OCEAN: CURRENTS . . . . .	73
8. CURRENTS IN DAVIS STRAIT, GREENLAND, BARENTS AND KARA SEAS . . . . .	79
9. POSSIBLE COURSE OF ANTARCTIC FOLD-LINES . . . .	89
10. ANTARCTIC SEAS: CURRENTS AND ICE . . . . .	95
11. THE ROSS BARRIER . . . . .	103
12. GREENLAND: ICE CONDITIONS . . . . .	107
13. DISTRIBUTION OF ESKIMO: PAST AND PRESENT . . .	148
14. SOUTH GEORGIA AND CHIEF WHALING STATIONS . . .	164
15. BRITISH DEPENDENCIES IN THE ANTARCTIC. (Reproduced by permission of Benn Bros.) . . . . .	176
16. NORTH ATLANTIC TRADE ROUTES AND AVERAGE POSITION OF ICE . . . . .	181
17. ROUTES IN THE SOUTHERN OCEAN . . . . .	189
18. GREENLAND: COLONIZATION . . . . .	194
19. NOVAYA ZEMLYA: SAMOYEDE SETTLEMENTS AND ICE-SHEETS	200
20. COAL-BEARING REGION OF CENTRAL SPITSBERGEN . . .	207
21. ARCTIC CANADA: NATIVE PRESERVES . . . . .	214

## FOLDER MAPS

NORTH POLAR REGIONS . . . . .	At end
SOUTH POLAR REGIONS. . . . .	" "



# THE POLAR REGIONS

## CHAPTER I

### POLAR REGIONS : THEIR EXTENT

**I**T is difficult to give any satisfactory definition of polar regions. The various phenomena that characterize polar regions have different boundaries against the temperate zones. The area of the earth's surface between the polar circles and the poles is .08 of the total area of the sphere or 15,755,260 square miles, but in no geographical sense can all that area be considered to be polar. The Arctic and Antarctic circles merely mark the equatorial limits of the zones in which the sun is never more than  $23^{\circ} 30'$  above the horizon. Within those zones there is at least one period of twenty-four hours in the year when the sun does not set and one period of twenty-four hours when it does not rise. At the Poles themselves there is a six-months' day, during which the apparent path of the sun is an ascending spiral from the vernal equinox to the summer solstice, and then a descending spiral till the autumnal equinox when the six-months' night begins. The length of continuous day and night within the polar zones depends on latitude. The circles are astronomical lines without climatic significance. In some places true polar climates undoubtedly extend to the equatorial side of the circles ; in others they cease on the poleward sides.

In the many attempts to demarcate climatic regions, a polar climate or climates, sometimes called by other names, are distinguished but their boundaries vary. A. Supan defines his Arctic province as never having a mean temperature of over  $50^{\circ}$  F. in the warmest month. His Antarctic province differs mainly in having a very low summer temperature. W. Köppen's snow climates (tundra and perpetual frost) differ

little from these five provinces of Supan, and have practically the same distribution, though Köppen finds the tundra climate also in the Himalayas and Andes but, like Supan, excludes Kamchatka. Again, A. J. Herbertson's natural regions include a polar type (tundra and ice-cap) which is essentially the same except that it includes the Yukon and Kamchatka and more of northern Canada than the others. E. de Martonne's *climat arctique* is more extensive and includes all northern and highland Scandinavia and much of the highland region of Central Asia and Canada as well as the regions accepted by Herbertson. Another definition of polar regions has been founded on the areas bounded by the average limits of floating ice. W. S. Bruce found this to be, on the whole, a satisfactory boundary for Antarctic regions. It includes, besides the Antarctic continent, all the island groups lying near the land, but excludes the scattered islands of the Southern Ocean. While the mean limit is in about lat.  $60^{\circ}$  S., the extreme limits may go as far north as  $55^{\circ}$  S., except south of the Indian Ocean and New Zealand. There can be no doubt of the true polar nature of the climate and correlated phenomena of the land areas embraced within the boundary of floating pack-ice. South Georgia and Bouvet Island which are more polar in appearance than any other islands far distant from the continent, come nearer than others to the northern limit of ice and so lie on the frontier zone.

In the Arctic, however, the definition of polar regions by the average limit of floating ice is less satisfactory, for it excludes much of the Barents Sea and includes Bering Strait and Bering Sea. But the main difficulty is that of course it gives no boundary in Asia and North America and so fails to define north polar regions in the greater part of their periphery.

More significant than the actual boundaries, on whatever basis they are drawn, is the realization that in each case the polar regions are practically treeless or at least are devoid of close or luxuriant tree growth. This feature implies certain climatic distinctions and has certain relations to animal and human life, though, of course, it does not constitute a definition of polar regions since hot lands can also be treeless.

The poleward areas beyond the limit of tree growth make a convenient and not unsatisfactory definition of polar lands.



FIG. 1.—Sketch map of the Arctic Regions showing the northern limit of trees and the southern limit of pack-ice.

These areas reach latitudes as low as  $60^{\circ}$  or as high as  $71^{\circ}$ . They include in the north Greenland, Spitsbergen and other islands of the Arctic Ocean, the Canadian Arctic Archipelago, the Ungava Peninsula, Labrador, Northern Canada and Alaska, and the coastal regions of Siberia and Europe as far west as the White Sea, but no part of western Europe. The northern parts of Iceland might be included. In the south the treeless criterion embraces the whole of the Antarctic Continent and adjacent islands as the South Orkneys, South Shetlands, South Sandwich and South Georgia, Bouvet, the Crozets, Kerguelen, Macquarie, etc., but not the Falklands where trees can grow, if with difficulty, and not Tristan da Cunha, Gough Island, the Aucklands, Campbell Island and Antipodes Islands which bear shrubs if not trees.

For many reasons, however, this grouping of lands is inconvenient and unsatisfactory for geographical purposes. To draw a frontier zone between arctic and non-arctic in Canada, Alaska and Siberia demands the mutilated treatment of regions which are more closely related physically and humanly with temperate lands. It would be better to say that certain temperate lands project into Arctic regions and that their Arctic interests are of small moment compared with their temperate activities. On the other hand, certain Arctic distributions like sea-ice or Eskimo overlap temperate regions and the full extent of their distribution must nevertheless be considered. It is therefore convenient to treat Arctic regions as defined above with the exclusion, except incidentally, of Alaska, the mainland of Canada and Siberia. In the Antarctic the girdle of ocean gives clear distinction to polar regions. Doubt arises only in regard to certain islands which are commonly, though perhaps inaccurately, termed sub-Antarctic.

Even this restricted area covers a considerable part of the globe's surface. The land area may be estimated thus:—Antarctica, 5,122,000; Greenland, 512,000; Spitsbergen, 25,000; Franz Josef Land and other islands, 65,000; Canadian Arctic, 1,000,000; total at least, 6,724,000 square miles of land or about 13 per cent of the land area of the globe, to which can be added about 13,000,000 square miles of ocean or about 9 per cent of the water area of the globe.

In the distribution of land and water there are striking con-

trasts between north and south polar regions. The north polar regions consist of an ice-covered sea almost completely girdled by continental land. In that sea, the Arctic Ocean, lie various groups of islands, large and small, which are all more or less accessible. None lies in the heart of the ice-covered sea, but all are strictly polar. The Pole itself is in deep water. Sea and not land is the predominant feature of the Arctic. In the south the principal feature is a great ice-covered continent on which lies the Pole. The continent is girdled completely by a great ocean which cuts off Antarctica from the nearest land masses. As the continental land in the Arctic may be looked on as the far northern edges of temperate land masses, so the ocean in the Antarctic may be regarded as the southern extremity of the great temperate oceans. In the one case land, in the other sea, are contributions from temperate regions.

As a result of these conditions further contrasts occur. The Arctic is a region of varied climates, and so of varied productiveness; the Antarctic has one climate that varies only in degree and is everywhere unproductive. The Arctic abounds in plant and animal life: the Antarctic, apart from the sea, is a barren desert. In the Arctic man can generally support himself: in the Antarctic he would be hard put to do so except on certain coasts and islands. Economic exploration of Arctic resources is several centuries old: but trade has never touched more than the fringe of the Antarctic: even exploration has been delayed until recent times.

Within the polar regions subdivision must be based mainly on physical grounds. The physical and biological factors are of far greater moment than man's distribution and disturbing influence. So far from man being supreme around the poles, his works are small and mainly recent. Nowhere else on the surface of the globe, unless it be on the oceans, is man so dwarfed by his surroundings as in polar regions. As a geographical agent he is almost negligible. That may be the reason why some exponents of the newest school of geography, with their tendency to indulge in moral speculation, find it convenient to ignore polar regions in their teaching.

Yet no parts of the world afford a finer field for the study of pure geography, for the basal training that is essential to advanced study. The pity is that so few teachers and students

have the chance of visiting them. It is even more difficult to visualize the polar regions than the tropics without some personal acquaintance. If the predominant note in the tropics is wealth and luxuriance of life, in the polar regions it is magnitude of physical processes. While in beauty of colouring, in delicacy of form and in grandeur of composition no parts of the world can equal the "two ends of our garden."

With the long record of British endeavour in polar work as an inspiration, it is surprising that there is no institute in our country devoted to the furtherance of knowledge of polar regions, not even a museum or a library specializing in polar science. Many years ago the late Dr. W. S. Bruce tried to found such an institute in Edinburgh in his Scottish Oceanographical Laboratory, where he collected a fine library of polar literature, specimens of Arctic and Antarctic natural history, and the equipment for the explorer. But the effort failed to draw the necessary financial support and had to be abandoned, the books, maps and specimens going to various public institutions in Edinburgh, enhancing polar collections already of considerable size, and making that city one of the finest centres for polar research, even though personal inspiration in the subject is lacking in its teaching bodies. A later effort which it is to be hoped will meet with success, is the Polar Research Institute at Cambridge, founded in memory of the late Captain R. F. Scott and his companions on the polar march.

A difficulty which most polar expeditions have had to face is the task of publishing their scientific researches. A popular work on the adventures of the expedition, especially if sensational, always finds a ready market, but the scientific results appeal to the few. If published in scientific journals they tend to be lost sight of, though accessible: if published in a series of special volumes the task is costly and the edition must be fairly considerable or the results will prove unobtainable by those who most require them. The results of many expeditions' work are still incomplete for want of publication funds; some will never be completed. Others, with the State behind them, like Scott's Antarctic expeditions and most foreign polar expeditions, have been able to publish, not merely in full, but with a lavish profusion of word and illustration.

## CHAPTER II

### A SKETCH OF ARCTIC EXPLORATION

**A**LTHOUGH he probably did not cross the Arctic Circle, Pytheas of Massilia may be regarded as the first Arctic explorer. The details of his voyage in the fourth century B.C. have been much disputed, but his Thule was probably Norway and the "congealed sea," which he heard of as lying to the north, was the Polar Sea. This would suggest that the early inhabitants of Scandinavia had already ventured far north across the sea since the pack-ice does not reach the coasts of north-western Europe.<sup>1</sup> Nansen has pointed out that Vikings crossed the North Sea in the sixth century A.D. or even earlier. There can be little doubt that in times as early Norse walrus hunters had reached Novaya Zemlya and possibly Spitsbergen. But all is vague and in the realm of conjecture as far as Arctic exploration goes until the days of Ottar (about A.D. 870 or 890), who may be regarded as the second Arctic explorer. He rounded the North Cape of Europe and discovered the Barents and White Seas. In the ninth century the Vikings reached Iceland, in the tenth Greenland and in the twelfth Svalbard, which was almost certainly Spitsbergen, and not, as has been suggested, Jan Mayen.

Widespread as were the Norse voyages of those centuries, they did not reveal any route into polar regions and still less the possibility of a route to lands beyond. Hafsbotn, the sea north of Norway, was evidently regarded as a gulf of the Ocean with continuous land on the north from Greenland to the east of the Barents Sea. In this state knowledge of north polar regions remained for many centuries. Even by the end of the Middle Ages the polar seas had not suggested a thoroughfare and had evoked little interest for their own sake.

<sup>1</sup> The possibility of climatic change offering another explanation is discussed on p. 47.

John Cabot's re-discovery of America, for the Vikings had certainly found it long before, by his landfall at Cape Breton in 1497, Gaspar Cortereal's sighting of Newfoundland in 1500, and the sighting of Greenland, possibly by J. Fernandez, the same year, paved the way for the Arctic explorations of the next four centuries. To what extent the old Norse discovery of Greenland and the American continent really influenced Cabot in drawing up the plans for his voyage can only be a matter of speculation. Yet it is significant that both Cabot and Columbus, the two pioneers in the Atlantic, had lived in Bristol and sailed in Bristol ships. For more than a century Bristol had been in trade relations with Iceland where the sagas kept alive the old Norse adventures. Among the sailors of the port, English and Icelandic, it is more than likely that tales were told of lands across the Atlantic. Earlier rumours persisting through centuries and emanating in unexplained sources may also have influenced these mariners; the Isles of the Blest of the Greeks, the Atlantis of Plato, the Isle of Brazil and others. Men who were adventurous enough to sail out into the unknown ocean would not be deaf to such tales and rumours.

When it was realized that the discoveries of Columbus, Cabot and others of their time were not parts of Asia, but a new continent extending from far north to far south, it became necessary to find a way past it. The Pacific was discovered and Cathay and the East were calling. Reports of fishermen who frequented the Newfoundland Banks, which Cabot had discovered, no doubt discouraged any attempt to find this route by the north. Unsubstantiated tales of Portuguese voyages as far as Hudson Strait cannot be accepted as evidence that in the early part of the sixteenth century there was any hope of finding a route to the west. Magellan in 1520 succeeded in finding one by the south and this, no doubt, for a time diverted any endeavour that might otherwise have been directed to the north. But before the end of the century the possibility of a North-West passage was suggested: the search for a North-East passage had begun. In both cases the motive was solely commercial in the hope of finding a route to the riches of the east—spices, gems, silks and other products of Cipangu, Cathay, and the Spice Islands.

Martin Frobisher in 1576 begun the long quest for the North-West passage. Later came John Davis (1585, 1586 and 1587) who made a real advance and reached lat.  $72^{\circ} 12' N$ . in Davis Strait; Henry Hudson in 1610, who entered the bay bearing his name, and William Baffin who in 1616 reached Smith Sound and turned back only after reaching lat.  $77^{\circ} 45' N$ . Baffin discovered Lancaster Sound, but did not guess that in so doing he had found the entrance to the passage he sought. It was rather from Hudson Bay that the strait was believed to lead. For a long period the quest was not pursued, the conditions seeming wholly unfavourable to a trade route.

The Muscovy Company of Merchant Adventurers, founded in 1553, played a great part in these early polar endeavours. Its foundation was a counterstroke to the Portuguese success in their eastern route, via the Cape, to India and China, discovered in 1497, and to the dominance of the Hanseatic League in English trade. In 1553 the Merchant Adventurers sent Sir Hugh Willoughby and R. Chancellor to search for a North-East passage. They discovered Novaya Zemlya and the White Sea and opened up a profitable trade with Russia. Three years later S. Burrough was no more successful in the main object of the quest, but in 1580 A. Pet and C. Jackman sailed into the Kara Sea. Sir Martin Conway notes that in 1584 one of the company's vessels reached the mouth of the Ob, where she was wrecked. Traders and walrus hunters of northern Russia probably had used the Kara Sea route for a century before this date.

Dutch rivalry in the White Sea now begun to be felt and Spain's prohibition of trade between the Netherlands and Portugal (1584) encouraged the Dutch to seek a polar route to the East. After some fruitless efforts via the Kara Sea, W. Barents tried a route due north across the Pole which led to the re-discovery of Spitsbergen in 1596. In 1607 H. Hudson reached lat.  $80^{\circ} 23' N$ . in trying the same route.

The famous map of Zeno, published in 1558 and attributed to an ancestor in the fourteenth century, is now recognized to have been a fabrication, but the map of Ortelius of 1570 is of value as showing knowledge up to that date. Greenland is an island with a strait between it and land to the south-west.

Land north of Greenland is said to contain "Pigmei," which suggests that Eskimo were then known.

The unpromising results of voyages to west, east and north diverted interest from polar regions in the early years of the seventeenth century. Throughout the remainder of that century and the greater part of the eighteenth century few additions were made to knowledge in the far north, except by sealers and whalers on the coasts of Greenland and in Spitsbergen. The one notable exception was in Siberian waters. The spread of Russian power in Asia gradually revealed the northern coasts of that continent and threw some light on ice conditions in the Arctic Ocean. But these discoveries only helped to dispel all hope of commercial routes in high latitudes. Among these Russian explorers the name of S. Deshnev deserves special mention, since it was he who in 1648 passed through the strait which nearly a century later received Bering's name.

The problem of the "passages" was attacked in a new quarter when J. Cook in 1778 passed through Bering Strait, looking vainly for ice-free ways to east and west. Cook's failure, however, meant the realization of the distinctiveness of Asia and America and the existence of a sea to the north of Bering Strait. These discoveries stimulated interest in the search which had already revived through the foundation of the Hudson's Bay Company in 1666. One of the avowed aims of the company was "the discovery of a new passage to the South Sea." It was, however, about a century after the charter had been granted that the company made any serious move in that direction. French penetration to the south and west of Hudson Bay and Indian reports of copper in the north first led S. Hearne in 1771 to reach the mouth of the Coppermine River on the shores of the polar sea. In 1798 A. Mackenzie, of the rival North-Western Company, descended the Mackenzie river to its mouth.

Arctic exploration now entered on a new phase. The sea channels free, or relatively free from ice, were known and had failed to yield the secrets of high latitudes. It was no longer possible to hope for any progress by avoiding ice, but had become necessary to navigate the pack, pushing through the ice in the hope of finding a way out or at worst being able

to retreat. There seemed to be little hope of finding a North-West passage of value to shipping, but the British Government not only offered a large reward for its discovery, but provided men and ships for the quest. Between 1819 and 1826 J. Franklin, J. Richardson and others discovered most of the "missing" coastline of northern Canada, and a few years later their work was amplified and extended by G. Back, P. W. Dease, T. Simpson and J. Rae. These efforts almost completed the survey of the Arctic coast of North America. But meantime the North-West passage had been very nearly discovered by sea when W. E. Parry in 1818 passed through Lancaster Sound and, making extensive discoveries, reached Banks (McClure) Strait in long.  $114^{\circ}$  W. where impenetrable ice forced him to return. With a little better luck, Parry would have reached Bering Strait. J. Ross and his nephew, J. C. Ross, in 1829 came almost as near to the discovery of the way when they found Franklin Passage, Victoria Strait and King William Land. J. C. Ross fixed the position of the North Magnetic Pole in Boothia peninsula in lat.  $70^{\circ} 5' \text{ N.}$ , long.  $96^{\circ} 46' \text{ W.}$

But if the western route promised to be valueless there was still a lingering hope that northward of the Greenland Sea there might be a way to Bering Strait. The separateness of Greenland and Spitsbergen was practically certain a few years after the voyages of Barents and Hudson, although more by tradition than belief the name Greenland for many years after was not infrequently applied to Spitsbergen.

J. C. Phipps in 1773, W. Scoresby in 1806, D. Buchan and J. Franklin in 1818 and W. E. Parry in 1827 each reached north of lat.  $80^{\circ}$ , Parry attaining lat.  $82^{\circ} 45'$  by leaving his ship and travelling with sledges. These journeys were the beginning of the long endeavour to reach a high latitude and the Pole itself, but they proved that line of advance to be impracticable.

Baffled in the north, exploration might easily have fallen again into abeyance had not interest in polar regions been kept alive by the Hudson's Bay Company's servants and above all by the success of the *Erebus* and the *Terror* in the Antarctic. Once again thoughts turned to the North-West passage, but there was no longer a material motive. By the nineteenth century polar exploration had become disinterested, although

it was many years before it became truly scientific in its methods and accomplishments.

The *Erebus* and the *Terror* sailed under Sir J. Franklin in 1845 to solve once for all the problem of a North-West passage. They took the Davis Strait and Lancaster Sound route which Parry had shown to promise success. The fate of Franklin and his men, not one of whom returned, proved a powerful motive in stimulating polar exploration at a period when it might easily have lapsed. The many search expeditions made far more important discoveries than Franklin's own expedition. By land, J. Rae, C. F. Hall, and by sea, a score of expeditions, among which stand out the names of L. M'Clintock, R. Collinson and R. M'Clure, eventually not merely pieced together the whole story of the Franklin disaster, but explored the greater part of the Canadian Arctic Archipelago. M'Clure entered the Arctic by Bering Strait and after two and a half years' extensive exploration was compelled to abandon the ice-bound *Investigator* on the north of Banks Island. He retreated with sledges eastward over the ice of Barrow Strait and eventually reached Europe in the *North Star* of Sir E. Belcher's squadron of search vessels. M'Clure thus made the North-West passage, partly in ship, partly on foot.

It remained, however, for R. Amundsen to take a vessel from Atlantic to Pacific by the north. In 1903-4 he took the *Gjoa* by Franklin's route and Dease Strait from Europe to Alaska. The North-West passage after centuries of suffering and high endeavour was accomplished. Even more important were Amundsen's researches in terrestrial magnetism. He fixed the position of the North Magnetic Pole in  $70^{\circ} 30' \text{ N.}$ ,  $95^{\circ} 30' \text{ W.}$ , which differs from the position determined in 1831 by Ross by only  $25'$  of latitude and  $1^{\circ} 16'$  of longitude. This showed that there is no suggestion of rapid secular change in the position.

In addition to their contributions to polar geography the Franklin search expeditions gave wide experience of sledging and Arctic travel generally, which paved the way for more adventurous advances on the inner polar regions and the Pole itself. It was sledging under most arduous conditions with man-hauling and the use of preserved provisions of little variety and not always of high nutritive value. But the task,

onerous though it was, suited well the British spirit which finds a certain joy in discomfort and the mastery of physical difficulties. Many of the journeys might have been less arduous and free from risk had the cause of scurvy been understood and men been less unwilling to live on seal, bear, musk-ox and bird flesh. A few expeditions used game extensively, yet most had not learnt that almost any bird or mammal is better fare than preserved food: and seals in particular are not scarce in most parts of the north. Rae set an example in "living off the land" and so travelling light and at a great speed, yet his example was but tardily followed: prejudice and lack of hunting skill were serious obstacles. M'Clintock was one of the few Arctic travellers of his day to follow Rae's example to which his successful journeys were largely due. It was the undoubted hardship and grave perils that beset the men of the Franklin and search expeditions which gave polar exploration the dangerous reputation which is still attached to it. The tradition lingers and will die hard.

There remained the North-East passage. C. Weyprecht and J. Payer when, in 1872, they took the *Tegetthof* to the north of Novaya Zemlya to explore the seas between there and Spitsbergen had this quest among other aims in view. In this they failed, but their discovery of Franz Josef Land in 1873 was ample compensation. The main features of this new land were explored by B. Leigh Smith in 1880 and 1881 and by F. G. Jackson in 1894-97, but the seas to the east are still imperfectly investigated. The actual accomplishment of the North-East passage was quite unsensational. In 1878-79 A. E. Nordenskiöld took the *Vega* from Europe to Japan via the Kara Sea and came home by the Suez Canal. The journey has since been made by other exploring vessels; the Russian expedition of B. A. Vilkitski in the ice-breakers *Taimir* and *Vaigach* in 1914-15, and R. Amundsen's *Maud* in 1918-20. Specially valuable in adding to the knowledge of the Arctic coast of Siberia was the work of the *Taimir* and *Vaigach* not only in 1914-15 but on shorter journeys in 1910, 1911, 1912, and 1913. In recent years Russians have again been paying attention to surveys on these coasts.

Expert opinion differed as to the most promising route for an advance on the Pole. It was generally agreed that there

was little likelihood of the polar seas being open enough to allow a ship to be taken near the Pole. The problem rather turned on the probability of finding land in a high latitude which could be used as a base. This, of course, entailed the desirability of reaching that land by ship. In Britain and America opinion was strongly in favour of the Baffin Bay and Smith Sound route. Quite apart from the attention the Franklin search expeditions had drawn to that part of the Arctic, Greenland and Ellesmere Island seemed to promise possible bases.

In Germany A. Petermann advocated the Greenland Sea route and on his advice the German expedition of K. Koldewey (1869-70) in the *Germania* and the *Hansa* tried to follow the east coast of Greenland to the north. They met with little more success than in an abortive attempt the previous year. The pack, drifting south along the east coast of Greenland, proved to be an insuperable and dangerous obstacle to progress beyond  $75^{\circ} 30' \text{ N.}$

Parry in 1827 had found the same southward flow of ice to the north of Spitsbergen, but this did not debar A. E. Nordenskiöld from proposing in 1872 to make a journey northward from Spitsbergen with reindeer sledges. The project was wisely abandoned and he turned instead to the exploration of the North-East Land in the Spitsbergen Archipelago. The last attempt to use this route was in 1900 when U. Cagni sledging north from Franz Josef Land reached lat.  $86^{\circ} 34' \text{ N.}$ , the world's northern record, and proved that Franz Josef Land is a relatively small archipelago.

The Smith Sound route appeared more promising especially after C. F. Hall in 1870-3 reached the polar basin, following in the footsteps of E. K. Kane and I. Hayes who in 1854 had discovered Kane basin and Kennedy channel. Hayes' mistaken report of an open polar sea which really referred only to Kennedy channel added attraction to this route. The way was thus prepared for (Sir) G. S. Nares in 1875 when he took the *Alert* through Smith Sound into winter quarters in lat.  $82^{\circ} 25' \text{ N.}$  This expedition added to the map of the north coast of Grinnell (Grant) Land, and A. H. Markham in 1876 broke the northern record by sledging to lat.  $83^{\circ} 20' 26'' \text{ N.}$  Nares considered that the prospects of reaching the Pole by

this route were poor, but his conclusions were not universally accepted and his failure provoked criticism and disappointment. In 1882 J. B. Lockwood of the American Greely expedition beat this record a little farther east by three and a half miles.

The discoveries and experiences of the Nares and Greely expeditions banished the hope of an open polar sea. When the pack drifts south along the channels to Baffin Bay there may be comparatively open water locally off north-west Greenland, but it is merely temporary. Realization of this truth was dawning, but on the other hand the Smith Sound route offered what no other route could afford, a high northern land base, from which to sledge to the Pole.

In 1886 R. E. Peary first turned his attention to Arctic exploration with work in Greenland. From time to time during the next twenty-three years he continued his explorations which became more ambitious with his growing experience. Geographically his most important work was in the north-east and north of Greenland, including two crossings of the island (1892 and 1895) and his discovery of its northern extremity in 1900. In these expeditions his heart was set on the Pole, and when the Greenland route did not afford the land access which he had hoped to find, he turned to Ellesmere Island and its possibilities for an advanced base. Meanwhile F. Nansen, throwing aside all the accepted canons of Arctic exploration, made a bold bid for a high latitude and the Pole itself. Nansen was convinced that a slow steady current set across the polar basin from the Asiatic to the Atlantic side. He found the most striking evidence of this in Siberian driftwood on the shores of Spitsbergen, in the wreckage of the *Jeannette* (p. 75) on the south coast of Greenland, and in the drift of the *Jeannette* herself before she was crushed in the ice in about lat.  $77^{\circ} 15' N.$ , long.  $155^{\circ} E.$ , off the New Siberian Islands. By using a ship constructed on suitable lines to rise under pressure, Nansen contended that he could drift across the Arctic Ocean, his vessel safely embedded in the ice. Instead of avoiding besetment in the pack, he proposed to court it: instead of battling with the drifting floes, he proposed to make use of their drift: instead of a long sledge journey, he proposed to stay in his ship. The plan met with much criticism, but Nansen persisted and eventually carried his expedition to a triumphant conclusion.

The *Fram* drifted from the New Siberian Islands to Spitsbergen in thirty-five months, her highest latitude being  $85^{\circ} 57' N.$  in October, 1895. Nansen with one companion made a sledge journey to lat.  $86^{\circ} 14' N.$ , the highest latitude reached up to that date. Five years later U. Cagni beat Nansen's record by 20' (see p. 14). Amundsen's expedition in the *Maud* (1918-25) later under the leadership of O. Wisting, set out to follow on the lines of Nansen's drift, but in the hope of drifting across the Pole. Unfavourable ice conditions hindered the voyage: several winters were spent on the Siberian coast and the drift followed roughly the course of the *Fram*. Direct geographical results were small, but the scientific researches were very valuable.

Nansen's journey was the first to penetrate the heart of the Arctic Ocean, which was proved to be comparatively deep. This disposed of the probability of land to the polar side of this track. De Long in the *Jeannette* had already in 1880-81 shown the non-existence of continental land associated with Wrangel Island. But there still remained the possibility of land in the Beaufort Sea and the extension of the Canadian Arctic island groups towards the Pole.

Peary's northward journeys from Grant Land (Ellesmere Island) in 1902, from Greenland in 1906 and his final journey from Cape Columbia to the Pole or its vicinity in 1909 dispelled the possibility of land in at least one part of the polar basin, for there seems no reasonable doubt that his report of Crocker Land in lat.  $83^{\circ} N.$ , long.  $103^{\circ} W.$ , was a mistake. In any case Amundsen's polar flight in 1926 failed to find any sign of its existence.<sup>1</sup>

O. Sverdrup and G. Isachsen, in a long series of explorations from 1899 to 1901, determined in all probability the north-western limits of the Canadian Arctic Archipelago, and V. Stefansson in recent years with even more certainty delimited its south-western extent.

The attainment of the Pole by Peary turned Arctic exploration into more strictly scientific channels. When once the great spectacular feats were accomplished there was more scope for serious research into definite problems and the investigation

<sup>1</sup> The claim of F. Cook to have reached the Pole must be dismissed as untenable in spite of various painstaking advocates.

of relatively small areas. Most notable were the efforts of V. Stefansson between 1906 and 1918 in the Canadian Arctic Archipelago and several Swedes (notably A. G. Nathorst) and various Danes in Greenland. Within the last twenty years the Danes have been very active in the exploration of Greenland, particularly G. C. Amdrup (1899 and 1900), M. Erichsen (1906-8) and E. Mikkelsen (1909-12), who completed the survey of the east coast, J. P. de Koch who crossed the inland ice in 1913, K. Rasmussen to whose work, between 1910 and 1919, is due a wealth of knowledge of Northern Greenland and especially the Eskimo, and L. Koch who also explored the north (1920-23). Lastly mention must be made of the work of the American, D. B. MacMillan (1913-17) in Ellesmere and adjoining islands, including his fruitless search for Crocker Land.

The most surprising discovery of new Arctic land within recent years was made 55 miles north of Cape Chelyuskin in Taimir Land in 1913 by the *Taimir* and *Vaigach*. This land, called Nicholas Land (since rechristened Northern Land), with two small islands nearer the mainland, has strangely eluded other exploring vessels as the *Vega*, the *Fram* and the *Zarya* (1900) which must have passed within a few miles of it. Its discovery shows how easy it is to fail to distinguish ice-covered land from ice-covered sea.

The twentieth-century explorer is far better equipped in knowledge, experience and appliances than his predecessor, although sledge travelling is still the chief method of progress. But sledging is not what it was in the past. The old plan, that persisted with rare exceptions, at least until the Nares expedition, carried with it the traditional dread of the polar night. At the end of summer an expedition "dug itself" into winter quarters, fearful of cold, darkness, and scurvy, and hibernated until the following spring. Nares stated that to begin sledging before April was nothing short of cruelty to the men, although L. M'Clintock had sledged as early as February in his Franklin search in 1859 with a mean temperature of  $-30^{\circ}$  F. In reality it is crueller to men to keep them imprisoned than to set them to work on sledging, since the old methods of inaction incur grave danger to health and spirits.

Peary often sledged in winter or early spring and even expressed a preference for that season on account of better

surfaces on the ice. On O. Sverdrup's expedition to the Canadian Arctic Archipelago sledge travelling was continued almost throughout the winter. And in the Antarctic during this century explorers have sledged in temperatures lower than any dreamt of in the north, without ill-effects as long as food supplies were sufficient and strength was maintained. Rae, as already mentioned, proved that a traveller can live on the land and so move quickly, unencumbered with heavy sledge loads and independent of supporting parties and depots of stores.

Nansen, Sverdrup, Isachsen and other Norwegians showed not only the value of dog sledges but the importance of travelling light and the possibility of living on game, seals and fish. Stefansson carried this method further, adopting Eskimo habits of diet, dispensing even with tea, coffee and tobacco, and thus becoming quite independent of a base and free to move for an indefinite period without serious inconvenience. This practice has the further advantage of eliminating all risk of scurvy.

It was the difficulty of long sledge journeys over rough drifting sea-ice and the frequent necessity of crossing open leads that led Nansen to adopt his method of drifting in the *Fram*, a method which the *Maud* with less success followed. The same difficulties have prompted other methods. Ice-breakers have been tried by the Russians, but they cannot penetrate far into old and heavy pack. The Russian ice-breakers in making the North-East passage in 1914 were forced to winter about 100 miles west of Cape Chelyuskin.

In this respect the Arctic, with its predominant sea, differs radically from the Antarctic where a desert of ice prevails and frequently makes communication between sea and land difficult if not impossible. Nor must it be forgotten that the practice of living off the country may serve well for a small quickly moving party but is valueless for a large party working in a restricted area. Such a party would soon exhaust the game and, as supplies diminished, would need to employ an increasing number of men solely for hunting, to the sacrifice of the scientific work. And even in the Arctic there are lands singularly devoid of game and certain seas in which seals are rare.

In 1897, when navigation in the air was in its infancy,

S. A. Andrée made a disastrous attempt on the Pole by balloon from Spitsbergen, and in 1910 W. Wellman proposed a journey by dirigible airship. With the developments in flying that are largely the outcome of the Great War, aeroplanes have been employed to greater advantage than these early unreliable machines, but they do not permit the detailed scientific work which is the chief need in modern polar exploration. R. Amundsen in 1925 made an unsuccessful attempt to fly to the Pole and back, merely proving that steering was difficult, that leeway was considerable and that consumption of petrol was more than he had anticipated. G. Binney, however, showed in 1923 the value of a seaplane in reconnaissance work in Spitsbergen, and in 1926 R. E. Byrd made a flight from Spitsbergen to the Pole and back, while R. Amundsen, U. Nobile and L. Ellsworth using a semi-rigid airship, *Norge*, succeeded in crossing the Pole from Spitsbergen to Point Barrow and Telfer in Alaska, travelling 2,300 miles in 72 hours. Daring, combined with a large measure of luck in weather conditions, carried them through.

Every age has its sensations; new means of locomotion have always been attractive to the adventurous. The flying machine has its value in polar travel for reconnaissance and prospecting the route, but the kind of exploration that is now required, with patient observation and accurate measurement, cannot be done by a quick-moving machine. Nor will it be possible till the problem of descent and ascent is solved. Coming years will no doubt see a great deal of flying in the Arctic. It is safe to say that from the point of view of scientific exploration most of it will have little or no value even though it may, and no doubt will, be useful in furthering knowledge of aviation. Unfortunately it will tend to divert funds from more useful kinds of work on land and sea in polar regions.

There is still some pioneer work of a geographical nature to be done in Arctic regions. V. Stefansson has pointed out that the asymmetry of Arctic regions causes the pole of inaccessibility to lie approximately in lat.  $83^{\circ}50'$  N., long.  $160^{\circ}$  W., that is, about 400 miles south of the geographical pole, on the Alaskan side. Around that spot lies a great area that has been inadequately explored. Not only is it less penetrable on account of heavy pack and distance from a convenient base,

but it lies far from the nations which have provided the majority of successful polar travellers, at least until the present century. Amundsen's flight took him rapidly over this area and he saw no land, but beyond that glimpse nothing is known. In more detailed and less sensational work there is endless scope for research, particularly of the kind conducted from fixed well-equipped stations maintained for a number of years.

## CHAPTER III

### A SKETCH OF ANTARCTIC EXPLORATION

WHEN the Greek astronomers conceived the world to be a sphere and Europe and Asia to lie in a northern hemisphere, they propounded in general terms the problem of the exploration of the south. Erastosthenes estimated that the habitable world, known to the Greeks, occupied only about one-quarter of the surface of the globe, and Pomponius Mela went further in postulating a southern *Alter Orbis*, inhabited but inaccessible. That was the beginning of the mystery of the Antarctic. Ptolemy's famous map marked a reversal of the older views in accepting a continuity of land over the face of the globe and the oceans as enclosed basins. This view implied the existence of land in the far south but it destroyed, for a time at least, the conception of another continent across the ocean.

In the Dark Ages the problem lay unattacked. The influence of the Church was hostile to so adventurous a conception as a spherical earth and an inhabited continent which Christianity had not reached. But by the fifteenth century the problem revived and began to move men's minds until it became eventually a great motive force in exploration and lured voyagers farther and farther into the unknown.

Vasco de Gama in rounding Africa in 1497 gave the death-blow to Ptolemy's conception of a southern continent joining Africa with Asia. But some years before this achievement the success of the Portuguese navigators in penetrating and crossing the torrid zone of the Atlantic had marked a great step in exploration by proving that the age-long dread of the tropics was untenable. The way to the south was open. Globes of Leonardo da Vinci (1515) and Schöner (1515) definitely showed a vast Antarctic continent based solely on man's credulity, but strange to say not grossly inaccurate in shape.

Early in the sixteenth century Spanish and Portuguese voyagers proved that South America extended far to the south, and when Magellan in 1520 found the long-desired strait through America he believed that Tierra del Fuego, to the south of the strait, was the great southern continent.

Several voyages in search of this southern continent placed various island groups on the map, each in turn supposed to be part of a great land mass. New Guinea and the New Hebrides thus had their day of importance in the quest. Drake, without rounding Cape Horn, proved Fuegia to be an island (1577). Australia had its turn till Tasman in 1642 sailed along the south and proved that New Holland had no far southern extension but suggested that his discovery of Staten Land (New Zealand) was the real South Land. In 1739 Bouvet,<sup>1</sup> discovering the island which now bears his name in the Southern Ocean, called it Cape Circumcision in witness of his belief that it was part of a great continent. The French navigator, Marion-Dufresne, in 1772 found the islands now called Marion and Crozet, but his name of Terre d'Esperance was symbolic of his hope that he had reached the threshold of the lost continent. The same hope inspired another and romantically minded French sailor, Kerguelen-Tremarec, to give a highly coloured account of his discovery of Kerguelen (La France Australe) in 1772. He reported it to promise "all the crops of the Mother Country" and to "furnish marvellous physical and moral spectacles."

More serious and far-reaching were James Cook's attempts to find the southern continent, and though their results were negative they laid the foundation of the exploration of the Antarctic. During his circumnavigation of the globe between 1772 and 1775 in high southern latitudes, Cook twice crossed the Antarctic Circle, being the first to do so, and made four unsuccessful attempts, in long. 39° 35' E., 95° E., 145° W., 106° 54' W. (and lat. 71° 10' S.) to push southward. Ice baffled him each time. He saw no land in the far south and so failed in his search for a southern continent, but proved conclusively that if such a land existed it lay in a high latitude, was probably ice-bound and certainly uninhabited.

<sup>1</sup> Bouvet is probably identical with Lindsay Island, discovered in 1808, and Liverpool Island, reported in 1825 (see p. 179).

Cook believed that no one ever would push farther south than he had done, but if he did "I shall not envy him the fame of his discovery, but I make bold to declare that the world will derive no benefit from it." He expressed the spirit of the age. On this voyage Cook found and named South Georgia which had been seen by La Roche in 1675 and possibly by Amerigo Vespucci in 1501. Cook's negative results and his somewhat gloomy reports of high southern latitudes discouraged further endeavour, and since it seemed that no immediate commercial gain would accrue from Antarctic exploration, the problems of the south ceased for a time to interest man.

Next in order of historical sequence come the sealers. When they first went to the Antarctic is not clear, but in the second decade of the nineteenth century American sloops were bringing sealskins from the far South Atlantic, South Georgia, and possibly other islands the existence of which, in fear of rivals, they kept a secret. This is one of the most fascinating chapters in the story of the Antarctic and one that is yet incomplete because the records of purely commercial voyages are difficult to trace after any lapse of time. In America E. S. Balch and in Britain W. S. Bruce have unearthed many facts of interest in searching old records and forgotten journals. The first outcome of these voyages was the discovery of the South Shetlands by W. Smith in 1819, the South Orkneys by G. Powell in 1821, and the first sighting of the Antarctic continent in February, 1820, by E. Bransfield, an Irish master mariner in the British Navy. Bransfield, when he saw and named Trinity Land, does not seem to have been aware of the importance of his discovery. His name for some time tended to be replaced by Palmer Land given by the American sealer, N. B. Palmer, a year later, but is now restored as the Trinity Peninsula of Graham Land.

Outstanding among the sealers was James Weddell of Leith. In 1821 he reached and named the South Orkneys six days after Powell had discovered them. But it was on his second voyage in 1823 that Weddell achieved fame. Leaving the South Orkneys for the south in search of new sealing grounds, he passed all previous records in these seas. Weddell had to bear eastward on account of ice, but about the meridian of 30° W. he found a clear sea and headed south.

Eventually he reached lat.  $74^{\circ} 15' S.$ , long.  $34^{\circ} 16' W.$  before he put about, and even in that high latitude the sea was almost clear of ice. This was not merely a southern record, but it dispelled the gloomy forebodings of Cook as to the possibility of a southern advance, and above all suggested an easy and inviting road to the Pole. Weddell certainly chanced on an exceptional year, for no later explorer has found the Weddell Sea, or George the Fourth Sea as he called it, so clear of pack-ice.

Before leaving the sealers certain others must be mentioned, although in chronological sequence their place is later. In 1830 John Biscoe, after visiting the South Sandwich group, discovered by Cook, bore away to the eastward and after some adventures in the ice discovered in 1831 Cape Ann, or as it is now called, Enderby Land, in lat.  $66^{\circ} 25' S.$ , long.  $49^{\circ} 18' E.$  This headland, which is undoubtedly part of the Antarctic continent, has never been revisited. Later in his voyage Biscoe added to the lands and islands of Graham Land. John Balleny was another sealer whose name is enshrined in Antarctic history. Like Biscoe before him, Balleny was encouraged by his employers, Messrs. Enderby, to make a voyage of exploration and in 1839 he discovered the volcanic Balleny Islands, which was the first landfall ever made within the Antarctic Circle to the south of Australia. A few days later he believed that he got a glimpse of more continuous land in Sabrina Land which, however, does not exist unless by chance Balleny was farther south than he thought at the time.

A few years earlier there reached the Antarctic the only Russian expedition that has ever visited the south. A whim of the Tsar, born no doubt of Russian experience and success in Siberian waters, led to Admiral F. G. Bellingshausen leading one of the first purely exploratory expeditions that went to the Antarctic (1819-21). In his daring circumnavigation of the world in a high latitude Bellingshausen's chief discoveries were Peter Island and Alexander Land in about lat.  $69^{\circ} S.$  to the south of South America. This was the most southerly land so far discovered and again raised suspicions of the existence of the lost southern continent although the voyage confirmed Cook's opinion of its southerly position.

Bellingshausen narrowly missed making even more important discoveries, for he cannot have been far from the edge of the continent in his attempt to push south in about the meridian of Greenwich. If he had tried a little farther to the west in all probability he would have discovered Coats Land.

The Victorian era opened hopefully in the elucidation of Antarctic problems. The voyages of the sealers were drawing to a close with the rapid extermination of the seals, but the day was dawning of exploring expeditions with no commercial ends in view. In 1838 Dumont D'Urville, leading a French expedition, aspired to follow Weddell's route to the south. He added to Bransfield's discoveries in Graham Land, but his attempt to push southwards in the Weddell Sea was half-hearted and had no result. Apparently he was disappointed in finding more ice than Weddell had experienced. However, D'Urville was more successful in 1840 in his discovery of Adelie Land, south of Australia. In the same year the American expedition under Charles Wilkes showed more enterprise and achieved greater success. Wilkes visited Adelie Land and traced the edge of the ice far to the west reporting several "high lands" or appearances of land in the direction of Enderby Land. So convinced was Wilkes of the continuity of these various lands that he called them the Antarctic continent. Some of his landfalls have since had to be erased from the map, but others may prove to be approximately correct. Most suitably this part of Antarctica is generally known as Wilkes Land, although strictly speaking the name was confined by Mawson to the coastline immediately west of Adelie Land.

While these expeditions were in the south another was on its way. This was the expedition despatched by the British Government in the *Erebus* and *Terror* under Sir J. C. Ross. It is worth noting that this was the only expedition to the Antarctic since Cook's for which the British Government was solely responsible. It was provided with stout wooden vessels, well staffed, equipped with scientific apparatus and led by an experienced polar explorer. Magnetic survey was in the forefront of the programme, but Ross was ordered to take his ships to as high a latitude as possible and to survey new coastlines. The expedition during three seasons in the south

circumnavigated the globe, and made three successful attempts to push far south. The first attempt in 1841 resulted in the discovery of South Victoria Land, landings on Possession and Franklin Islands, the discovery of the great Antarctic volcanoes, Erebus and Terror, and the remarkable Ice Barrier at the head of the Ross Sea. The following season Ross returned south from New Zealand in order to make a further examination of the Barrier, and attained the southern record in lat.  $78^{\circ} 9' 30''$  S., long.  $161^{\circ} 27'$  W., and found an "appearance of land" to the east of the Barrier. This must have been the lofty nunatak discovered by Amundsen's expedition south-east of the Bay of Whales.

In 1843 Ross made his last attempt towards the south. After some minor discoveries around Graham Land the ships succeeded in making southing in relatively open water on the east of the Weddell Sea and reached lat.  $71^{\circ} 30'$  S., long.  $14^{\circ} 51'$  W. before pack-ice compelled them to turn. He saw no land or appearance of land, and was in ignorance of being within 40 miles of Coats Land. The ice that stopped him was packed against the land as Bellingshausen had found before him and as Bruce found some sixty years later. The chief result, however, of this Weddell Sea voyage was Ross's report of a depth of 4,000 fathoms, no bottom, in lat.  $68^{\circ} 14'$  S., long.  $12^{\circ} 20'$  W. For more than half a century this great depth figured on charts, and the existence of the so-called Ross deep compelled geographers in drawing the probable outline of the Antarctic continent to place its coastline at the south of the Weddell Sea in about lat.  $80^{\circ}$  S.

After these fruitful years came a long period during which the Antarctic attracted little attention and no ship ploughed its waters or battled with its ice. All endeavours on the part of men of science to evoke a response to their appeals for further exploration fell on ears that refused to listen. Largely due to the disappearance of Sir J. Franklin with the *Erebus* and *Terror* the Arctic drew all attention and all the men the world had to spare for polar work. A hurried visit of a few days' duration of the *Challenger* when in 1874 she crossed the Antarctic Circle by a few miles in long.  $78^{\circ} 22'$  E., was important in showing to what use a steamship and modern scientific instruments could be put in Antarctic exploration, but the

ship was not built and was never intended for Antarctic research. A result of more far-reaching importance was the interest it awakened in Sir (then Mr.) John Murray, one of the naturalists on board. With his warm enthusiasm and his forceful personality Murray became during the next thirty or forty years one of the most tireless advocates of Antarctic exploration.

But Murray's voice in Britain and Dr. G. von Neumayer's on the continent were equally in vain. Basing his beliefs on the few lands known in the south, the distribution of ice, the scanty geological evidence obtainable, the rock fragments dredged from the ocean floor, and the nature of deep-sea deposits, Murray argued (1886) that there was a great Antarctic continent and drew its probable outline. Murray's suggestions have suffered few considerable modifications in the light of later discovery.

A few adventurous sealers and whalers on the search for new grounds brought the only additions to knowledge of the Antarctic for several decades. In such enterprises exploration is merely incidental, but in unknown seas something of value is almost certain to be learned. Captain E. Dallmann in 1874 made some discoveries in the Graham Land region, including Bismarck Strait, a name which indicates his nationality. More important were the Scottish and Norwegian whalers (especially *Balaena*, *Active* and *Jason*) around Graham Land in the summers of 1892-93-94 when W. S. Bruce showed what could be done in collecting and observing under the most discouraging conditions, W. G. Burn-Murdoch produced one of the most vivid polar volumes ever written,<sup>1</sup> and Captain C. A. Larsen discovered Oscar Land (probably New South Greenland of the old-time sealers) and Foyn's Land. Thus began the discovery of the western shores of the Weddell Sea which, however, on account of heavy ice congestion has never progressed much further to this day. In the Ross Sea Captain L. Kristensen with C. E. Borchgrevinck, on an unsuccessful whaling venture, called at Possession Island and Cape Adare in the *Antarctic*, where the first landing was made on the mainland of the Antarctic continent (1895).

A day of greater effort and more useful expeditions was at

<sup>1</sup> *From Edinburgh to the Antarctic*, W. G. Burn-Murdoch (1894).

hand. Doubt as to the existence of a southern continent had practically vanished. Murray's outline was generally accepted as an approximation to the truth. The main problem before the explorer was no longer the search for a continent signalized by endeavours to push south in various longitudes where the ice permitted. The day of circumnavigation in high latitudes was over. It was now more useful to get to grips with the continent, to choose a likely line of approach in the hope of effecting a landing and conducting exploration of the coasts and interior. Moreover, the *Challenger* demonstrated the many physical problems awaiting solution on land and in the sea, and the wealth of the marine fauna. These problems could be investigated only by an expedition which was prepared to localize its efforts. The day of intensive exploration was beginning.

Belgium led the way in 1898 with the *Belgica* (A. de Gerlache and G. Lecointe), which visited the western side of Graham Land doing much surveying, making large biological collections, and bringing home the first series of long-continued meteorological observations ever taken in the far south, for this expedition, drifting with the pack, was the first to experience an Antarctic winter. A year later C. E. Borchgrevinck in the *Southern Cross* made the first wintering on the continent, at Cape Adare in Victoria Land, and paid a visit to the Barrier, making a landing and a short journey over its surface.

With the opening years of the twentieth century came a golden era in Antarctic exploration. The chief north polar problems were solved or on the eve of solution, but no one had yet penetrated the Antarctic continent, while the spread of scientific interests made it increasingly necessary to investigate causes and effects in an unknown area covering several million square miles. In Britain Sir J. Murray and Sir C. R. Markham were tireless advocates, and in Germany Dr. von Neumayer had never ceased his efforts, and in Sweden long and honourable associations with north polar regions found an echo in the south. The outcome of these efforts was the sailing of several expeditions. Between the leaders there was no rivalry but only a desire to co-operate in a common cause. The unknown area was big enough for all, and the problems

to be solved were numerous enough for a score of expeditions. The attainment of the Pole was not definitely part of the programme of any expedition. The *Discovery*, the British expedition under Captain R. F. Scott, 1901-4, made for the Ross Sea, the region where Ross's work had staked out a claim for British endeavour. They investigated Victoria Land and the Ice Barrier, confirming Ross's suspicions by the discovery of Edward Land. A southern journey over the Barrier reached a world's record in  $82^{\circ} 16' 33''$  S., and established the extension of the Victoria Land plateau well to the south. A journey was also made on the height of the plateau to the west of winter quarters in McMurdo Sound. The German expedition sailed in the *Gauss* under Dr. E. von Drygalski, but beyond discovering Wilhelm Land (1902) in a region where land was expected did little geographical work. Dr. O. Nordenskjöld, who led the Swedes in the *Antarctic*, did useful, if unsensational, work around the east of Graham Land (1902-3), specializing in geological research. Dr. W. S. Bruce, who had the hardest task in raising funds, led the Scottish expedition in the *Scotia* in 1902. He chose Weddell's route and in two seasons made the first scientific exploration of the Weddell Sea. It fell to Bruce's expedition to make the most striking and unexpected discovery of the edge of the continent in lat.  $74^{\circ}$  S., long.  $20^{\circ}$  W. (Coats Land), thus adding an enormous area to its probable dimensions.<sup>1</sup> A French expedition under Dr. J. Charcot (*Français*) explored on the west of Graham Land in 1903-5. All these expeditions spent one or more winters in the Antarctic, and all being supplied with scientific staffs brought home vast collections and many scientific data.

This campaign should have been continued by new expeditions on a large scale, for the problems to be solved were now more definitely formulated. Funds however were lacking except for a few modest efforts. Charcot in the *Pourquoi*

<sup>1</sup> The practice of using the name of Coats Land for all the land on the south-east of the Weddell Sea is not only a tribute to the pioneer work of Bruce, but avoids the unfortunate multiplicity of "lands." These are now known as "coasts," Caird Coast and Luitpold Coast, as well as Bruce Coast for the part of Coats Land originally discovered. An alternative suggested by W. H. Hobbs is to speak of the Coats, Caird and Luitpold Coasts of Bruce Land.

*Pas?* (1908-10) continued his valuable work on the west of Graham Land, and Mr. (later Sir) E. H. Shackleton, who had several years earlier accompanied Scott, made a definite attempt to reach the Pole (1908-9) using McMurdo Sound as a base. He added considerably to the map of the land on the west of the Ice Barrier and sledged over the high plateau to lat.  $88^{\circ} 23' S$ . Another achievement of Shackleton's expedition was a journey over the ice-cap to the South Magnetic Pole under the leadership of Prof. (later Sir) Edgeworth David. The position was fixed in lat.  $72^{\circ} 25' S$ , long.  $155^{\circ} 16' E$ , which was north-west of the position determined by the *Discovery* expedition on observations at a distance. The *Discovery* position had been about 200 miles east of the position decided by Ross in 1841, so that evidently the Pole is not a fixed point but an area in which the actual Magnetic Pole moves.

After the attainment of the North Pole by Peary in 1909, the one great spectacular feat in polar exploration was a journey to the South Pole. On this expedition Shackleton found the route for such a journey and showed its arduous nature. Captain R. F. Scott's expedition in the *Terra Nova*, in 1910-13, had this journey in the forefront of its programme, and on those grounds alone could the return to such a well-known district as McMurdo Sound be justified on the part of an expedition relatively well supplied with funds. Using Shackleton's route Scott reached the Pole on January 17, 1912, only to find that Captain R. Amundsen, who had been landed by the *Fram* and wintered at the edge of the Ice Barrier, had reached there thirty-four days earlier, on December 14, 1911. Amundsen chose a new route due south from his winter quarters and revealed a considerable new area of the edge of the Antarctic plateau. Some of his party also explored in Edward Land. The fate of Scott and his four companions on their return journey marks the only disaster of such magnitude in the annals of Antarctic exploration. The *Terra Nova* on her homeward journey made a notable addition to the north of Victoria Land in Oates Land.

Dr. (later Sir) D. Mawson, who had been on Shackleton's expedition and had reached the South Magnetic Pole, led an Australasian expedition to Wilkes Land in the *Aurora* (1911-14) which added a great deal to the coastline of Antarctic in George

and Mary Lands, while Captain J. K. Davis, the master of the ship, conducted valuable oceanographical work. Dr. W. Filchner in the *Deutschland* in 1912, wisely choosing the Weddell Sea as affording the greater likelihood of striking discoveries, extended Coats Land to the south-east by his discovery of the Luitpold coast and found the southern boundary of the Weddell Sea in the Weddell Barrier in about lat.  $78^{\circ}$  S. Three years later Sir E. Shackleton added the Caird Coast between the Bruce and Luitpold coasts of Coats Land in his expedition in the *Endurance*. His vessel, like most of the other ships that have ventured far into the Weddell Sea, was caught in the ice, and had the misfortune to be crushed.

The Antarctic continent has never been crossed. Bruce prepared plans for a crossing in 1908 from the Weddell Sea to the Ross Sea, a distance of at least 1,800 statute miles, but could not raise funds for the attempt. Shackleton in 1914 had the project in view, but had to abandon it. There is no value in such a traverse for its own sake, but it would entail at least one new track to the interior. Each new route means further knowledge, and it is on the Atlantic and Pacific sides that knowledge is most meagre. A crossing via the Pole has the advantage of allowing the last half to be over a known track on which food depots would be placed from the far end, a most important consideration on so long and arduous a journey. And it is not without importance to include in the programme of an expedition, a project for a spectacular journey. Efforts of that nature are far more likely to hold public interest and secure financial support than research of a strictly scientific nature. In Britain especially unsensational scientific endeavour solely in the cause of knowledge generally appeals in vain for funds.

In geographical exploration there is still a great deal to be done in the Antarctic. Certain regions on account of ice congestion have been much neglected and could probably be most safely explored by way of the land ice from accessible bases. In this respect the aeroplane, which so far has not been used in the south, should be of great service in preliminary reconnaissance and even for the general charting of coast-lines. But what is more requisite for good work is some means of reliable mechanical transport for sledge parties.

Dogs are useful enough to those who are accustomed to manage them, as Amundsen showed, but their area of action is limited by the amount of food which they require. Machine-drawn sledges would require fuel, but the carriage of relatively light fuel should not seriously limit the radius of their use. The mechanism, whatever it is, must be strong, simple and trustworthy. A breakdown beyond repair in such transport far from the base would prove fatal to the men involved. Therein lies the whole problem of mechanical traction. Is it safe to rely on a machine? Is the margin of safety not too narrow when the only line of retreat on the machine giving way is to continue on foot, hauling the sledges? It is all a question of reasonable risk, for risk there must be on any journey of this kind. A man can know his own measure, but he can never know the measure of the machine's capacity. The machine is bound to introduce an uncertain element in the calculation and so increase the risk of failure as well as the chance of success.

## CHAPTER IV

### POLAR CLIMATES

**A**LL polar climates have a long cold winter, but the length, and, of course, the darkness and the degree of cold vary. During the winter, where insolation is either entirely wanting or very weak, radiation causes a steady fall in temperature and this would continue far, as it does in Eastern Siberia, where it may fall to  $-60^{\circ}$  F., if it were not for cloud formation which checks the fall. In Ellesmere Island, with more or less continental conditions, January means of  $-55^{\circ}$  F. and  $-60^{\circ}$  F. have been recorded, but near the sea, even if ice-covered, the mean of the coldest month is generally much higher, e.g.  $-35^{\circ}$  near Cape Chelyuskin ;  $-32^{\circ}$  during the drift of the *Fram* in the Arctic Ocean ;  $-11.5^{\circ}$  in Franz Josef Land (Cape Flora) ; and  $-8.3^{\circ}$  in Green Harbour, Spitsbergen. On the south-west of Greenland the winter mean on the islands and coast of the generally open sea is some seven degrees higher than the temperature a few miles up the fjords ; while the summer mean on the coast is about four degrees lower. On the west coast of Spitsbergen, a south-west gale blowing over the warm waters of the Spitsbergen current, may raise the temperature above freezing-point even in mid-winter. Low absolute minima of  $-50^{\circ}$  or  $-60^{\circ}$  are occasionally recorded in Arctic regions, but these are rare, and temperatures almost equally low may occur as absolute minima in much lower latitudes.

Winter temperatures in the Antarctic, again at sea-level, do not as a rule fall much lower than in the Arctic. Thus the mean of the coldest month is  $11.1^{\circ}$  at the South Orkneys ;  $-14.5^{\circ}$  at Cape Adare, Victoria Land ;  $-14.6^{\circ}$  at McMurdo Sound ; and  $-48.6^{\circ}$  on the edge of the Ross Barrier. Absolute minima of  $-73^{\circ}$  and  $-77^{\circ}$  have been recorded on the

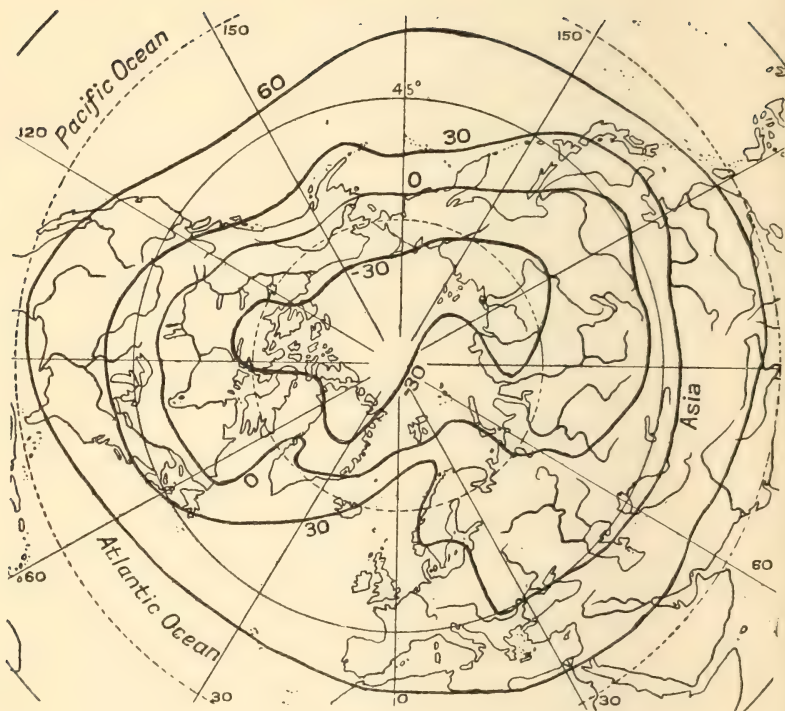


FIG. 2.—Approximate Isotherms in Arctic Regions—January (degrees Fahrenheit)

Barrier in mid-winter: from the high plateau there are no winter records, but very low minima must occur.

There is little relation between latitude and temperature in polar climates, and there is no marked contrast in mid-winter between the north and south. The difference between the climate of Arctic and Antarctic lies mainly in the length of winter. Arctic temperatures at sea-level show a mean above freezing-point during the warmest month and there are few places that do not have three or at least two months with a mean above  $32^{\circ}$  F., a temperature which even the drifting *Fram* experienced in July. As a rule the mean of an Arctic July ranges between  $36^{\circ}$  and  $40^{\circ}$ , and maxima vary between  $55^{\circ}$  and  $60^{\circ}$ . On the other hand, no month in the Antarctic has a mean above freezing-point. Summer in the south is an astronomical conception: it is warmer than the winter, but is nevertheless a cold period. At Cape Adare the warmest month shows a mean of  $31.6^{\circ}$ ; at McMurdo Sound  $24.9^{\circ}$ , and at the Barrier edge  $19.9^{\circ}$ . Even at the South Orkneys in lat.  $61^{\circ}$  S., the warmest month has a mean of only  $32.7^{\circ}$ , and in no other month does the mean rise above freezing-point.

In the Antarctic the great ice-covered continent acts as a reservoir of cold. The summer insolation has little effect on melting its surface and the surface air currents are chiefly southerly and so cold. Hence snow lies practically at sea-level throughout the year and temperatures remain low. The effect of adiabatically heated winds on snow and ice is referred to later (p. 44).

Polar temperatures might rise considerably higher in summer if they depended solely on insolation. But the winter snow on the glaciers, ice-fields and pack-ice, protect the underlying soil and water from direct insolation and maintain a temperature not higher than freezing-point. When the low-lying Arctic snow has melted by late June, the soil is saturated with ice-cold water so that even then the air temperatures rise but slowly. Dry soil, bulbs of plants, and objects lying on the ground may be heated to  $60^{\circ}$  or  $70^{\circ}$ , while the air temperature is no higher than  $38^{\circ}$  or  $39^{\circ}$ . The *Belgica* recorded a black bulb temperature of  $113^{\circ}$  F. with an air reading of  $31.6^{\circ}$ . There is thus a bodily sensation of

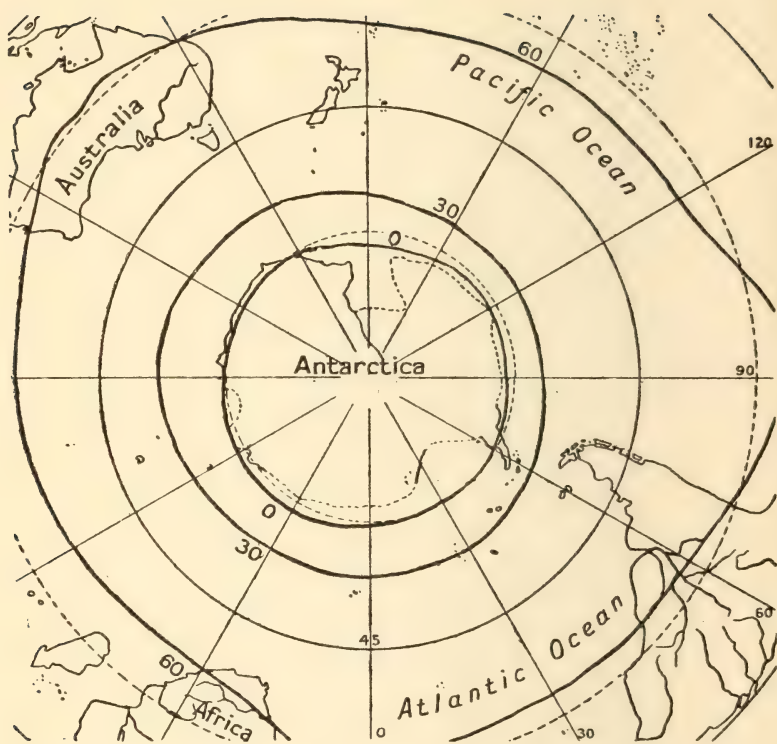


FIG. 3.—Approximate Isotherms in Antarctic Regions—July (degrees Fahrenheit)

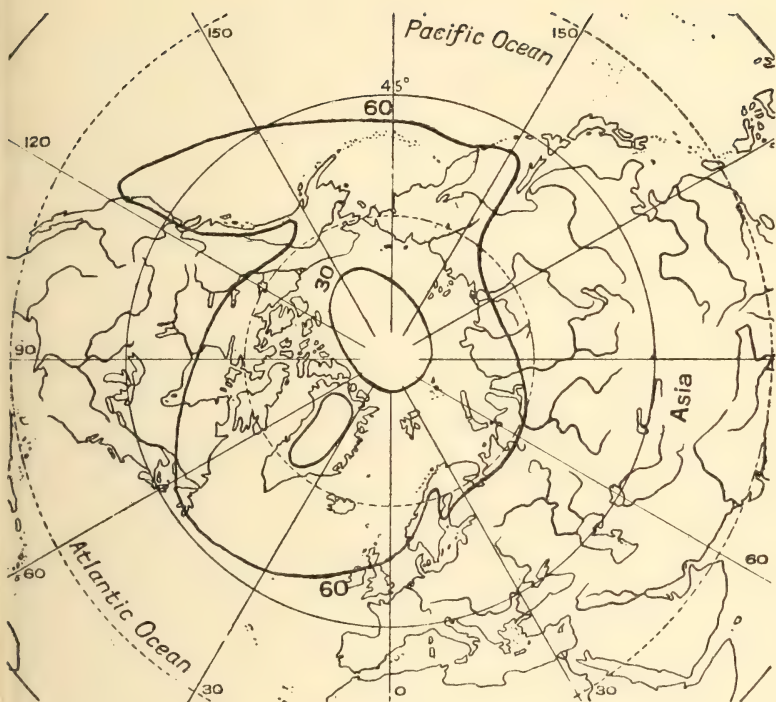


FIG. 4.—Approximate Isotherms in Arctic Regions—July (degrees Fahrenheit)

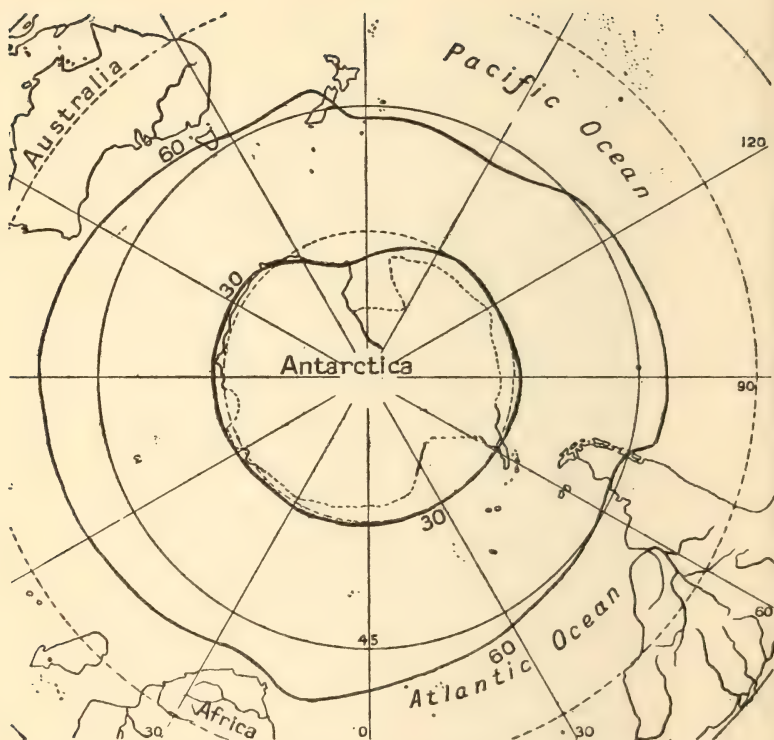


FIG. 5.—Approximate Isotherms in Antarctic Regions—January (degrees Fahrenheit)

warmth in calm summer days in the Arctic which is incommensurate with the low air temperature.

A calm warm period in July or August leads to rising air under which cold heavy air currents pour in from the sea or the glaciers, causing the formation of mist and low clouds and temperature inversions. At 2,000 feet it may be fine, and sunny and calm, while below lies a bank of cloud, and underneath it is cold, damp and rough weather. A mixing of these strata even by a cold northerly wind, causes a rise in temperature. It is probable that everywhere in polar regions where an extensive surface is covered by snow or ice this inversion of temperature occurs. In winter when the loss of heat is most rapid it is most marked. H. U. Sverdrup made a close study of this phenomenon during six years in the Arctic Ocean on the *Maud*. He found that the winter air temperature was always lower close to the ice than 1,000 feet higher. At the surface the mean was  $-19.1^{\circ}$ , or in calm weather  $-27^{\circ}$ , at 445 feet it was  $-9.0^{\circ}$ , at 3,200 feet it was  $-4.5^{\circ}$ , and above that level it decreased slowly. The low temperatures on calm days were due to cooling by contact with the ice which lost heat by radiation, but also gained heat by conduction from the underlying water at  $29^{\circ}$ . By this compensating action the surface air never fell lower than  $-50^{\circ}$ . Independent of the direction of the wind this temperature inversion was found to be characteristic except that high winds led to somewhat higher temperature at the surface, a fall to about 300 feet and then the normal rise to some 3,000 feet. Again, in the Antarctic at Cape Evans there was a winter surface temperature of  $-45^{\circ}$  rising to  $-30^{\circ}$  at 1,000 metres and steadily falling at higher altitudes. The explanation is the same as in the Arctic. Thus a surface temperature of  $-35^{\circ}$  rose, with a strong southerly wind, to  $-15^{\circ}$  in twenty-four hours and to  $+5^{\circ}$  in thirty-six hours. The absence of inversion in summer may be due to the position of this station being near the edge of the open sea. In any case a summer blizzard caused a fall in temperature. The German Antarctic Expedition of 1912 found comparable inversions at Vahsel Bay in the Weddell Sea. They have been observed also near the margin of the inland ice of Greenland.

The occurrence of lower winter temperatures in eastern

Siberia, where the thermometer frequently falls to  $-70^{\circ}$  and may reach  $-90^{\circ}$ , than over the Arctic Ocean, is explained by C. H. Pollog as due to the different effects of frozen sea and frozen land. As a result of the water below the ice, as explained above, the air temperature over the ice cannot fall as low as over the land where there is no influence at work to check fall of temperature due to radiation. Pollog also points out that the contrast between the temperatures over the Arctic Ocean and eastern Siberia would be even greater than it is, if it were not for the difference in latitude.

While ice is a good conductor of heat, snow is bad. This accounts for the remarkable diurnal range of temperature at times observed over the Ross Ice Barrier which reached an average amplitude of  $20^{\circ}$  between day and night, at a period when the sun was shining throughout the twenty-four hours, but was, of course, higher at midday than at midnight. The Barrier being composed largely of snow and not solid ice receives no heat from the sea below by compensation for the loss of heat by radiation.

The cold air of polar regions can carry little water vapour in suspension, but its relative humidity may be high. This has the effect of making the cold far more endurable than it would be with higher temperatures with a greater degree of humidity. On glaciers and snowfields, where the vapour-pressure cannot exceed that for a temperature of  $32^{\circ}$ , the air may become particularly dry in summer.

With low absolute humidity precipitation in polar climates is slight and generally in the form of snow or very fine ice-crystals. Rain is confined to the summer months in the Arctic and practically never falls in the Antarctic. Precipitation is very difficult to measure when it falls as fine snow during high winds. Not infrequently it is almost impossible to be sure whether the driving snow is a new fall or drift from a previous fall. All measurements and estimates, however, point to the equivalent of some 10 or 12 inches of rain, at the most, as the annual precipitation in Arctic, and 8 to 12 inches in the Antarctic. This figure is exceeded only where cyclonic disturbances invade polar regions, as on the west coast of Spitsbergen or the South Orkneys. In winter all the snowfall collects on the surface: in the Arctic much of it

melts in summer, all in fact on the lower ground: in the Antarctic there is little true melting except on occasional mild days. But around both Poles snow on ground sloping towards the sun disappears in summer by sublimation even while the air temperatures are below freezing-point. Thus, although the Antarctic climatic snow-line is at sea-level, there are snow-free patches in midsummer. In many Arctic lands the surface is free from snow at all seasons owing to the high winds.

Fog is a common occurrence in polar regions, especially where warm air inflowing from lower latitudes over open water meets cold air over pack-ice or glaciated land, as in summer in Arctic seas. Bear Island, Prince Charles Foreland and Jan Mayen are examples of islands in the Greenland Sea that are frequently wrapped in fog. The fogs of Labrador and Newfoundland are notorious. In the south, islands like the South Orkneys have their full share of fog. As a rule this fog is low, sometimes only some 30 to 50 feet in thickness, and it tends to roll to and fro in banks with the faintest air currents.

The old conception, still prevalent in text-books, of low-pressure conditions in polar regions must be abandoned. It would be true if it were not for the presence of vast snow and ice surfaces which cool the air and give high-pressure conditions. Pressure is not always remarkably high, but it is relatively very high compared with the low pressures that are constant in the North Atlantic and North Pacific and over the Southern Ocean. In the Arctic it may never be so high as the winter pressures in Siberia and North America, but it is always higher than the pressure over the oceans, or the summer pressure over the adjoining continents. The extent of the high-pressure area varies, but in the polar basin where it is persistent there is little seasonal range, although frequent cloudy conditions in summer suggest cyclonic invasions from time to time. Travelling cyclones in the North Atlantic pass easily into the "gulf of warmth" over the Greenland and Barents Seas and occasionally, as Nansen found, invade the inner polar regions. He had no perfectly clear days from June to September, but an average of fifteen a month in midwinter. Precipitation also fell on twice as many days in

summer as in winter. During the long drift of the *Fram* more winds with a southerly than a northerly component were experienced. This may have been due to comparative proximity to open or partly open seas to the south with their cyclonic invasions. During her expedition to the Canadian Arctic Archipelago from 1898-1902 the *Fram* met more northerly than any other winds except in June, a month when pressure would naturally be at its lowest in the far north. In any case, the general prevalence of light north-easterly winds over the Arctic Ocean confirms the existence of a high-pressure area with, as a rule, a gentle gradient.

The idea of an Antarctic anticyclone which was first tentatively suggested by G. von Neumayer in 1872 has been established by the researches of the present century. This anticyclone, like that over the Arctic, is due to radiation from the ice-covered continent and is not dependent on the high elevation of the ice-cap. It varies in extent, being most widely spread in winter when it may continue over some of the ice-covered seas of the Southern Ocean. The high pressure over the continent gives rise to the prevailing southerly winds that blow off the continent, generally with an easterly component due to deflexion by the earth's rotation, but sometimes with a westerly component, the latter perhaps the result of local topography. They blow normally with the strength of gales with intermittent blizzards which all south polar expeditions have experienced. On Adelie Land D. Mawson recorded wind velocities of 80, 90 and even 116 miles an hour. The average wind velocity for the year was 50 against an average in Europe of 10 miles an hour. Such also were the blizzards with which Scott and Shackleton had to contend on their polar journeys over the high plateau.

Lastly, in confirmation of this air circulation over the ice-cap are the observations that the upper air currents feeding the anticyclone are more or less opposed in direction to the surface ones. This has been shown by the use of balloons, and is seen in the direction of clouds and the smoke of the lofty volcano of Erebus.

On the equatorial side of the Antarctic anticyclone pressure is low, and gulfs of low pressure extend from the Southern Ocean, into the Ross, Bellingshausen and Weddell Seas, giving

rise to clockwise winds which lead to the peculiar distribution of ice in those seas. In lat.  $83^{\circ}$  S. the Scott expedition experienced in midsummer a northerly blizzard with temperatures as high as  $33^{\circ}$  F. due to a vast low-pressure area over the Ross Sea.

In the circumpolar belt of low pressure characteristic of the roaring forties and shrieking fifties, there is a continual procession of cyclones, many from west to east, sweeping over the sub-Antarctic islands and occasionally impinging upon but never able to invade the Antarctic continent with its high pressure. This belt of raging winds and storm-tossed seas must be traversed by every Antarctic exploring ship, as many a deep-laden vessel has proved to its cost.

The anticyclone over Antarctica is repeated on a smaller scale over Greenland with similar effects on atmospheric circulation and a system of outpouring air currents.

On these facts W. H. Hobbs has based his theory of glacial anticyclones in which he seeks to explain the blizzards characteristic of the ice-caps in terms of the cold winds descending the ice slopes under the force of gravity, that is to say, katabatic winds. He goes further in maintaining that the polar anticyclones are confined to and caused by the dome shapes of the ice-cap, and he denies the occurrence of relatively high pressure over the Arctic Ocean.

Antarctica and Greenland, according to Hobbs, are poles of wind flow; from their lofty ice-domes cold heavy air glides slowly downwards gathering speed as it advances. It moves outwards to the sea, its course being determined by the slope of the ice-cap, by local gradients and topographical features, and to a certain extent by deflexion due to the earth's rotation. These are the prevailing south-easterly winds that blow off the Antarctic continent.

As the cold air advances it gathers speed, and where the gradient is steepest, that is, at the edges of the ice-cap, its highest velocity is attained. The fall of the air leads to adiabatic heating: eventually this becomes sufficient to overcome the low temperatures due to contact with the cold surface: the downrush stops: calm supervenes until surface cooling, which at once begins anew, leads to another downrush of air and a renewal of the blizzard. Thus, according to

Hobbs, develop the strophs of the thermo-dynamic engine, which manifest themselves in alternations of calm and blizzards. The adiabatic heating of the air leads to the föhn-like effects which are often noticeable on the coasts of Greenland and Antarctica.<sup>1</sup> In Greenland these mild winds have particular significance in relation to human life in many of the coastal settlements. Hobbs finds in this occurrence an explanation of the well-known inversions of temperature, which he suggests are due to the violent downrush of relatively warm air overriding the cold stagnant air masses that lie round the lower edges of the elevated ice-domes.

In the interior of this anticyclone air currents are drawn downwards to replace the outflowing air on the surface. These down-flowing currents, drawn from the top of the troposphere, carry with them minute ice spicules such as are found in cirrus clouds. By adiabatic heating the ice spicules are turned into water and vapourized, but on the air being cooled again by the cold surface of the ice-dome the moisture is precipitated in fine snow. This deposition occurs mainly in the central parts of the anticyclonic area, but some of the snow is carried centrifugally outwards. Hence an explanation of the relatively high humidity and the mist that several explorers have found in the interior of Greenland, and the light variable winds, overcast skies and falling ice spicules that Scott reported on the Antarctic plateau.

Hobbs' theory thus reconciles the existence of an anticyclone, which is not disputed, with the occurrence of precipitation, and so overcomes the great difficulty of explaining the alimentation of the ice-caps. His anticyclone is not an area of predominant evaporation, and so the ice-cap, instead of being starved of moisture, can grow, in fact has grown under these conditions.

In criticism of this theory it may be noted that the high pressure in the Arctic is not confined to Greenland, but, as explained above, occurs to a modified extent over the Arctic Ocean, and, further, that, being due to radiation from a cold

<sup>1</sup> The fantastic theory of C. R. Markham that these warm, damp southerly winds experienced at Scott's winter quarters in the Ross Sea are evidence of an open polar sea to the south, need only be mentioned to be discredited.

surface, would occur over Greenland and Antarctica even if the cold surface were at sea-level. A more important objection to the acceptance of the theory in full is offered by G. C. Simpson, who points out that katabatic winds require that radiation from the surface layers must exceed radiation received, and that this does not occur in the meteorological condition before and during a blizzard. He holds that above the glacial anticyclone with its general outward air motion along the ice surface "a cyclone forms on account of the relatively rapid vertical pressure change caused by the cold dense air." This cyclone supplies the air which passes outwards near the surface, and on the Barrier is instrumental in causing the well-known blizzards. Over the Barrier surface cold stagnant air collects during fine weather, the lowest layers being the coldest and most stagnant by reason of their density. On low pressure developing over the Ross Sea, a not unusual occurrence at all times of the year, the upper layers of air begin to slide over the lower layers on the Barrier, and are fed all the time from the air on the plateau. For a while there is calm at the surface though the upper air is in rapid motion. Eventually the lower dense layer is disturbed, broken up and mixed with the upper air currents. Then the blizzard starts suddenly with an appreciable rise in temperature due to this mixing of very cold with less cold air. From the ascending air currents moisture falls as snow.

Another explanation must be found for the blizzards of Adelie Land, owing to the different conditions of relief in which they occur, and it may be found, when all the data are available, that Hobbs' theory fits the facts.

Evidence appears to show that not only does precipitation occur in the anticyclone, but also in quantities sufficient to add to the growth of the ice-cap. Simpson, however, doubts that the ice spicules, on which Hobbs insists, are the chief source of precipitation on the plateau although they do fall. He believes that appreciable precipitation can occur only during a general ascent of air, and so occurs during blizzards. De Quervain has shown that in Greenland cyclonic depressions reach the edge of the ice-sheet and may even cross it, and to these winds he attributes the main snowfall.

Beyond the high polar pressures are the areas of low pres-

tures over the oceans with their series of moving cyclones. The cold air from the high pressures pours into these cyclones, intensifying and revivifying them and adding to their fury. It has long been noted that the föhn winds on the south-east of Greenland synchronize with the passage of strong cyclones along that coast, and H. Rink recorded the same phenomenon on the south-west coast as far back as the middle of last century. The almost equal prevalence of gales in summer and winter in the Southern Ocean may be associated with the slight seasonal changes in the Antarctic anticyclone. While the greater storminess of the North Atlantic in winter than summer may well be due to the considerable reduction in area, if not in intensity, of the Arctic high-pressure area. This seasonal contrast in the North Atlantic is an objection to Hobbs' insistence on Greenland being the only high-pressure area and only centre of outflowing winds in the north, for if that was the case the small seasonal change in the Greenland anticyclone should result in small and not considerable seasonal changes in North Atlantic storminess. But in any case it is along the line of meeting of the cold polar air and the warmer air from lower latitudes, which V. Bjerknes called the polar front, that the travelling cyclones characteristic of temperate latitudes develop. These belts of cyclonic activity mark the tropical limits of polar influences and the polar limits of the anticyclonic conditions of subtropical zones. On a small scale commensurate with their limited areas, phenomena comparable to those of Greenland and Antarctica have been noted on the ice-caps of North-East Land, Ellesmere Island, and the northern island of Novaya Zemlya.

The sub-Antarctic islands of the Southern Ocean show an oceanic modification of the climate of Antarctica, especially in their winter temperatures. South Georgia (of course at sea-level) normally has means below freezing-point during June and July, and more rarely during May, August and September, but in no month does the mean show more than five or six degrees of frost. In the warmest month the mean rises to only ten degrees above freezing-point. Kerguelen has a summer mean of about  $45^{\circ}$  and a winter mean of  $36^{\circ}$ , while Macquarie likewise shows a range of means from  $45^{\circ}$  to  $38^{\circ}$ . Precipitation is heavy: at South Georgia 56 inches, and at

Macquarie Island 46 inches a year, and strong westerly winds and gales prevail throughout the year. In many respects the term sub-Antarctic is open to criticism, and from a climatic view the objections are strongest, since the Antarctic climate is essentially continental and the most marked characteristic of the climate of these islands is its oceanic nature. In another chapter it is shown that the vegetation of the islands is far from suggesting the vegetation of Antarctica. But the term must stand for want of another: it has at least the merit of suggesting the geographical position of the islands.

Much controversy has ranged over the likelihood of changes in climate in polar regions. Certainly in past geological periods both polar areas have frequently experienced warm and even tropical conditions. This is evident from palæontological records, such as the Cretaceous and Tertiary floras of Greenland or the Cretaceous, Jurassic and Tertiary floras of Graham Land, Antarctica. In fact, the geological record shows that glaciation has been the exception rather than the rule in the Antarctic. These, however, are problems for geologist and astronomer. Geographically the question of climatic changes is narrowed to recent times and more especially the human period. Is the climate changing now and if so in what direction? Provided that past climatic changes can be established there, is an *a priori* reason to assume that the underlying causes, whatever they may be, have not ceased to act. Evidence of some importance has been obtained from Greenland. The early Norse settlers in the tenth century may have found opener conditions than now obtain since they kept sheep and cattle, and tried, not apparently with great success, to grow a little grain. On the east coast they founded no permanent settlement, doubtless on account of the difficulty of access, and though early accounts of Greenland have little to say about sea-ice, there are many records in the Icelandic Sagas of voyagers to Greenland being shipwrecked, in all probability through entanglement with pack-ice or collision with bergs (p. 193). The *King's Mirror* (A.D. 1250) describes the ice of the East Greenland current and its dangers.

Researches of P. Nörlund, of which a fuller account is given on p. 196, point with more certainty to climatic changes having occurred. In excavating an old Norse churchyard at

Herjolsfnes, west of Cape Farewell, he found that many of the coffins, now lying in continuously frozen soil, were embedded with the roots of plants, thus showing that in the fourteenth and fifteenth centuries, dates derived from inscriptions, vegetation was more luxuriant and the soil less deeply frozen. From other parts of the Arctic historical evidence is less satisfactory.

When the Vikings colonized Iceland in the ninth century they found it clothed with forests, no doubt of birch, but they could grow little corn, the springs were cold, and there was much ice in the sea. The English and Dutch whalers of the seventeenth century and the Russian trappers of the eighteenth century in Spitsbergen appear to have experienced essentially the climate of to-day.

In spite of the scanty evidence, at least from Arctic regions, C. E. P. Brooks, O. Pettersson and others believe that climatic fluctuations have been established both within and before the human period. Brooks finds that a warm, dry climate, which set in about 3000 B.C., began to deteriorate about 850 B.C., and was replaced gradually by a more oceanic climate with heavier precipitations and lower temperatures. This was the Twilight of the Gods, when the legendary civilization of Scandinavia passed away. A warm, dry period again set in about A.D. 200 and lasted till about A.D. 1100, and then once more a deterioration of climate began and is apparently continuing. These fluctuations have been studied more particularly in the North Atlantic region and Europe, but their incidence, if they took place, must have been more widespread. Even more alluring as regards the Arctic are Brooks' conclusions regarding sea-ice. He believes that the Arctic Ocean must either be covered by its present extent of floating ice or be practically free from ice: no intermediate stage can be stable. A rise of only 6° F. in the mean winter temperature would dispel the ice and give an ice-free ocean. This was the state of affairs in the warmer periods indicated in his cycle of climates. The possible fluctuations in Arctic pack-ice are discussed on p. 81. Whether the theory is tenable or not on physical grounds may be argued, but there is little historic evidence in its favour.

More climatic data from polar regions are needed. Scat-

tered observations of a few months or even a few years are far less useful than continuous records from well-equipped permanent meteorological stations. There are few of those within true polar climates. In 1882 there was a scheme of international co-operation on a magnitude never since attempted in scientific research. On the initiative of Germany, a plan for observations, including permanent and temporary stations, was adopted. Eleven States dispatched expeditions, and many others co-operated through observatories already established. The stations were as follows: Austria-Hungary at Jan Mayen; Finland at Sodankyla in Lapland; Germany in Cumberland Gulf, Baffin Island, at Nain in Labrador, and in South Georgia; France at Orange Bay, Cape Horn; Great Britain and Canada at Fort Rae on the Great Slave Lake; Norway at Bossekop in Lapland; Russia at Sagastyr in the Lena delta and at Karmakul Bay in Novaya Zemlya; Sweden at Cape Thordsen in Spitsbergen; Denmark at Godthaab in Greenland and on a ship that drifted in the Kara Sea on her way further east; Holland on a ship bound for Dickson Island at the Yenisei mouth, but which also drifted in the Kara Sea; and the United States at Point Barrow in Alaska and at Discovery Harbour in Grant Land (Ellesmere Island). Most of these stations functioned only one year, but their work laid a sure foundation except for the true Antarctic.

In 1903 W. S. Bruce built and started an observatory in Scotia Bay, South Orkneys, where the *Scotia* wintered during her explorations in the Weddell Sea. He gave it to the Argentine Government, which has since maintained it, changing the staff annually. That is the only permanent Antarctic observatory, but on South Georgia there has been an Argentine observer at one of the whaling stations since 1907, a condition of whaling leases being that meteorological observations shall be taken.

In the Arctic there are more permanent observatories, not to mention several on the fringe of the polar regions. At Spitsbergen, from which there are numerous observations, there has been a Norwegian observatory at the radio station in Green Harbour since 1911, and for some years there was another in King's Bay. There are also stations at the coal mines at Advent Bay (Longyear) and on Bear Island. The

Germans had a station at Ebeltoft Haven in Cross Bay from 1912 to 1914. On the island of Jan Mayen, Norway erected a station in 1921 which, like the other chief Norwegian station, has wireless communications. Lastly, Norway founded an observatory on the coast of East Greenland in lat.  $73^{\circ} 30' N.$  at Mygbugten (Mackenzie Bay) near the mouth of Franz Josef Fjord in 1922, but has not continued it. When the relief ship failed to get through the ice in 1923 the staff of the station, in trying to make south along the coast, perished in the pack-ice. Russia has maintained with greater or less regularity for some years observatories at Dickson Island at the Yenisei mouth ; at Khabarovo at the entrance to the Kara Sea, and in Novaya Zemlya on Matochkin Shar. The Danes take many series of meteorological observations at their stations in Western Greenland.

## CHAPTER V

### OTHER ATMOSPHERIC PHENOMENA

#### Aurora Polaris

**A** STRIKING phenomenon of the Arctic skies is the Aurora Borealis or Northern Lights. It is not unknown in lower latitudes, as in Norway and Scotland, where it is frequently seen and appears even as far south as the Mediterranean ; but is at its brightest during the Arctic night. In the southern hemisphere the Aurora Australis has been less often observed since there are no inhabited lands in high southern latitudes. Observations are mainly confined to exploring expeditions, and observers who have seen both the northern and the southern displays agree that the latter are comparatively poor and unimpressive.

The aurora takes various forms and sometimes even appears as a faint diffuse light, so weak that it may be overlooked if the moon is shining. More commonly it takes the form of luminous bands or rays or even a distinct arch of which both ends approach the horizon. Sometimes the bands appear as curtains of waving drapery, and at other times rays dart rapidly across the sky, giving the illusion of rays of a distant searchlight. Whatever the form may be there is always movement and generally rapid change.

The auroral light is white, tinged with yellow or red and more rarely green and violet. Opinions vary as to the intensity of the light. In Greenland, where it is common, the light is said at times to exceed that of the moon and to be bright enough to cast appreciable shadows. But as a rule the light is less than the moon at quarter, and is nearly mastered and lost by the moon at full. At Cape Evans in the Ross Sea the presence of even a little twilight was sufficient to obscure all but the brightest auroras. At Cape Adare, however, they were much brighter and more coloured.

The crackling or rustling sounds that are often said to accompany auroral displays are by no means established. It is difficult to be sure that such sounds are not due to some wholly different causes. Certainly there are many records of auroras during which no sounds could be heard. Various observations on the height of the aurora, as a rule the lower band, which is most distinct, show that it is comparatively high above the earth. The average altitude is about 65 miles and there does not appear to be any well-recorded instance of displays much lower than 50 miles. It is possible then that the noises would be audible only in very intense displays and under certain atmospheric conditions. But 65 miles is certainly a long way for any sound, that could reasonably be caused by the display, to be carried. On at least two expeditions to Victoria Land there have been records of auroras much lower than the general average, and intervening between the observer and distant mountains. These may possibly be due to optical illusions. Simpson maintains that it was due to reflected moonlight on the foothills of the mountains.

The association of auroras and magnetic storms has long been noted, although this is not always obvious in auroral displays in high latitudes. In Norway the telegraph system is sometimes seriously interrupted, and in Australia similar disturbances have been reported to occur synchronously with exceptional auroral displays in Victoria Land. This, of course, shows that the aurora is in some way due to an electrical discharge. There is, however, no proof of the old time belief of seamen that the aurora is the forerunner of bad weather. It is no more responsible for weather changes than for the evil events in human affairs which it was supposed to portend.

From time to time various explanations of the aurora have been given, and it is now generally accepted that it is caused by emanations from the sun which move towards the earth at a high velocity and are ionized as pressure decreases during the passage. On entering the earth's atmosphere and coming under the influence of the earth's magnetic field, they arrange themselves in spirals round the lines of magnetic force. The luminosity is caused by collision with matter during the rays' passage through the earth's atmosphere, and the spectrum of



FIG. 6.—Sketch map showing areas of auroral frequency in the northern hemisphere

the aurora shows a prevalence of nitrogen lines due to the occurrence of crystals of nitrogen in the outer atmosphere.

Emanations from the sun are known to occur in the vortical disturbances that are the cause of sunspots, and a relation has been established between the aurora and sunspot periods. It may, therefore, be said that the emanations from the sun, which eventually cause the auroral displays, are due to disturbances in the sun, but that the display as seen on earth, that is to say the luminosity, is a terrestrial phenomenon. It is, however, noticeable that auroral displays at Cape Evans were as frequent in 1912 as in 1911, although fewer sunspots were observed in the later year. This suggests the independence of auroras from sunspot activity, and there is some evidence for supposing that from some one or other spot of the earth's surface auroral display can always be seen. The position of the pole of auroral frequency in the northern hemisphere lies in about lat.  $81^{\circ}$  N., long.  $70^{\circ}$  W., which is in Ellesmere Island or about twenty-six degrees east and considerably north of the Magnetic Pole. The zone of maximum frequency passes south of Greenland through the Ungava Peninsula and Hudson Bay, across the Mackenzie mouth, north of Alaska, Siberia and Novaya Zemlya, north of Europe and south of Iceland. In both directions from this belt the frequency diminishes. On the south of it auroras are generally seen to the north, and on the north generally to the south.

In Antarctic regions it is not yet possible to give the areas of frequency beyond a statement that displays are numerous in Victoria and Wilkes Lands, which are near the Magnetic Pole, and rare in Graham Land on the opposite side of the Pole.

### Mirage

Mirages are frequently seen in polar regions. The whalers used to rely on mirages to tell them the whereabouts of other ships of the fleet that were out of sight even from the mast-head. Not infrequently to a moving ship pack-ice appears to bar the way, but it is only a mirage of ice far away. Or a point of land may appear to have grown where there was water a few hours before. Vision plays strange tricks with the traveller in polar regions until he learns to make full allowance for mirage.

The phenomenon depends on rapid changes of density of

the air with increasing altitude. When the decrease is gradual no sudden bending of the light rays takes place and no mirage occurs. But the inversion of temperature, which is characteristic of many weather conditions in polar regions, means that a dense cold layer gives way at a certain altitude to a warmer stratum at a lower density, with the result that the rays are bent back towards the earth. This may result in objects below the horizon being projected within the vision of the observer at sea-level, or if the change in density is more rapid, the object may be seen in an inverted image, sometimes above the actual object seen by direct vision. The flickering due to convection currents, which is common in hot deserts, is seldom seen in polar regions. The "looming" of objects or their elevation by mirage above their true position is well known to sailors in all seas and is not infrequently their first indication of the approach to land.

Another phenomenon due to refraction is the appearance of the sun above, when theoretically it should be below the horizon. Astronomical refraction alters the apparent place of all celestial bodies near the horizon. An allowance, ranging from 0' at the zenith to 34' on the horizon, has to be made in all observations. But the special importance of it in polar regions is that the sun actually appears a day or two after it should have set in winter and reappears a day or two ahead of time in spring. Thus the polar day is lengthened.

## CHAPTER VI

### SEA-ICE AND ITS NATURAL HISTORY

**T**HE freezing-point of water falls as its salinity increases. With sea water of average salinity it is about 29° F. In polar seas the salinity is low owing to the great inflow of fresh water and the low evaporation. Consequently polar seas freeze relatively easily. When the temperature falls low enough, generally to about 29° F., in sheltered inlets or lanes among the old pack, ice begins to form. The first sign is an oily or opaque appearance of the water due to the formation of ice spicules which rapidly increase in numbers until the sea is covered with a layer of plastic ice, known as bay-ice. Snow falling on this layer may add to its thickness and produce what is termed slush. Bay-ice growing in thickness, especially without the addition of snow, loses mobility, wave motion passes easily through it, but pulling of a boat is impeded, and a large ship may "lose way." If bay-ice forms when no snow is falling, it looks dark and receives the name of black ice, really because it is translucent. But the surface is never smooth and hard: it is always rough and sticky, due to the salts having been precipitated on the water congealing. Bay-ice forms in the middle of summer in the Antarctic, but at that season it is generally broken and not infrequently melted before it can grow to a later stage. As the bay-ice forms it tends to divide into hexagonal plates, three or four inches or a foot or more in diameter. These plates, rolled against one another by the slightest movement, for no water is quite still, have their edges rounded and turned up. Thus the cakes of ice known as pancake-ice are formed. When the frost continues these pancakes freeze together and become loaded with snow until eventually they form floes or fields of ice. A land floe is an area of ice which has formed along the land and remained in position. Moving floes form the pack-ice which drifts with wind and current.

Ice may grow in thickness as much as four or five inches in forty-eight hours. Its rate of growth depends on air temperature, salinity and wind velocity. A thick covering of snow delays growth by preventing the passage of heat through the ice.

The ice which has grown in thickness all winter may have reached five to seven feet by summer, but its growth does not stop. The sun's warmth melts the surface snow which runs off the edge of the ice into the sea, lowering the surface temperature at times low enough for new growth of under layers of fresh water ice. So that at the end of the summer the floe may actually have gained in thickness in spite of surface wastage. In autumn this process ceases and growth does not begin again till the low temperatures of winter cool the surface layers of the sea. Koch points out that in the north of Greenland, in lat.  $83^{\circ}$  N., the snow lying on sea-ice begins to melt in July and in about a week forms pools on the surface. These pools have a temperature of about freezing-point, ice frequently forms on their surfaces and they protect the underlying ice from direct insolation. Melting of the floes takes place only on a small scale. As a result ice in the polar basin, if level enough, has a sledging surface at least till mid-summer.

Nansen records a floe 13 feet 10 inches in thickness as being four years old. This represents more than the average thickness of Arctic ice by straightforward growth without piling or rafting. And it must be remembered that downward growth is limited by temperature: a few feet below the surface the normal temperature is above the freezing-point of salt water ( $29.3^{\circ}$  to  $29.1^{\circ}$  F.). In the Antarctic the maximum thickness of Weddell Sea ice after one season's growth is about 5 feet, but goes over 15 feet, representing several years' growth, have been measured.

The actual level of the ice is often below the waterline owing to the weight of accumulated snow it bears, covering entirely the inequalities and roughness of the original surface. Near the limits of the pack, that is, near the open sea where snowfall is generally heavier than in the heart of polar seas, the accumulation of snow is most noticeable, but rarely if ever is a true ice, as distinguished from snow-surface visible on pack-ice after the first few days of growth.

Depression of the ice below sea-level results in the flooding

of its surface layers. The sea water mixing with the snow produces a solution of low salinity and so of relatively high freezing-point. Thus a floe may add to its thickness by growth from above. This increase has frequently been noted in the Antarctic, especially in the Weddell Sea and off Wilhelm Land, where the snowfall is relatively great. The more usual mode of growth is by the addition of bundles of ice crystals to the under surface of the floe. Another method which has been noted in the Ross Sea is by the rapid addition of frazil crystals below, frazil being the term applied to fine crystals forming well below and rising to the surface.

Sea-ice, except in very sheltered bays, is liable at all times to break up and drift under the influence of tide, wind and ocean swell. This drifting pack-ice may be driven against a coast or a stranded berg. As a result, piling, screwing and rafting occur, floes being forced one over the other or turned on end. The longer the pressure lasts the greater the chaos produced: a release in pressure causes the pack to spread, and open water, termed lanes, may occur between the piled up floes. This happens even during the low temperatures of mid-winter. Old ice of several seasons' age nearly always shows signs of pressure in the occurrence of hummocks 20 to 50 feet or even 100 feet in height which are remains of pressure ridges. Detached hummocks are often referred to as floebergs, and are not to be confused with icebergs or their fragments known as growlers, which are of glacier origin. The palæocrystic ice north of Robeson Channel and Greenland, reported by the Nares Expedition of 1876, has probably not earned its name. It is not several centuries old but merely pack, that has undergone a few years' heavy pressure in being driven towards a lee shore and has had its hummocks worn by rain, thaw, and driving snow. The ice, by long continued drainage in the hummocks, has assumed a granular appearance like glacier ice. Pressure ridges are generally highest near shore and lower far from land, where they are seldom over 30 feet. There are, however, well-authenticated instances of pressure ridges so lofty that they obscured the view from the mast-head of vessels 60 to 100 feet above the water.

Thin sea-ice of less than six inches is seldom hard or resistant and cannot safely bear the weight of a man, though if

mounted on ski, which distributes the weight, he might cross rapidly. Six-inch ice bends under the weight and is too frail for a heavy-loaded sledge. The danger in crossing thin sea-ice is reduced if its width is narrow, for as long as the sheet remains unbroken it will bear. But in a wide area the sea swell may break such ice before the traveller has crossed, and if breakage once begins it spreads rapidly. Old solid pack with a thick covering of snow filling up some of the minor inequalities is best for travel, but the older and more solid the floes the greater the liability to formidable ridges which may cause a few miles' progress a day to be a ceaseless struggle. In 1925 Amundsen, about 136 miles from the Pole on the European side, found very rough hummocky ice and no large smooth floes, while on the other hand Peary covered over 25 miles a day on some stretches of his march to the Pole in 1909. When thick ice breaks under the influence of swell there is comparatively little danger to a sledging party, since even a small floe will serve as a refuge until it floats or is paddled to a larger one. But with thin ice this means of escape is impossible.

It is pack-ice that closes the polar seas to navigation and guards the inner secrets of the Arctic basin, and the course of the Antarctic coast-line. A vessel can safely penetrate drift-ice or loose pack, but an ordinary iron or steel vessel without adequate strengthening or wooden sheathing, runs a grave risk if the floes are hard, close or in rapid movement. A steel ice-breaker is of no greater value than a well-found wooden ship built for polar work, especially if the latter is small and has considerable engine power. For such a vessel, which is essential for a polar expedition, the danger lies not in meeting wandering floes but in being caught in pack-ice drifting before a strong wind. This may result in the vessel being imbedded in the pack. Safety then depends on her ability to rise under pressure, the ice meeting below and lifting her out of the water. If this does not occur the vessel will ultimately be crushed, unless the pressure slackens. More than one exploring vessel and many whalers have thus met their fate. A skilful ice navigator, provided his ship is sound and powerful, will contrive to find a passage through pack so close that scarcely any water is to be seen. A description of the ice-master's tactics, by W. S. Bruce, based on his wide experience of the work in northern

and southern seas, illustrates the means employed: "One piece, a heavy-looking mass, may be charged and will be shattered; another, a wise ice-master will avoid charging because he knows it is of steely hardness and that his ship will make no impression upon it. . . . A good ice-master will nose his ship through ice that would seem to one without experience absolutely impenetrable, and he will go through narrow lanes that are not as broad as the beam of his ship, first getting the starboard bow of the ship against an obstinate piece and working it away in among its fellows and then pushing another piece similarly aside with the port bow. Then the ship is brought to a standstill with the engines going full speed, but bit by bit one sees a heavy floe beginning to rotate, and finally, by its motion and momentum, cleaving a way through which the good ship steams ahead. Now possibly comes a difficult place: two heavy floes have met at two points and there is open water beyond; screwing the ship is of no avail; the engines are stopped and reversed, when the 'go astern' is given. Then she charges full speed at the 'neck of ice,' and, when the shock comes, trembles from stem to stern, the masts and yards shake violently and the crew are almost thrown off their feet, but there is no visible effect on the ice. This operation is repeated a second and a third time, and the narrow neck of ice between the two floes shows signs of cracking. Once more astern! Once more full speed ahead! The ice shivers, the neck breaks, and the gallant ship is in the open water that she has fought so hard to reach." Thus a stout wooden ship can hammer and pound a passage through the ice.

The inmost parts of the polar basin have never been penetrated by a ship. As a free moving agent no vessel could reach them. Nansen's attempt with the *Fram* and Wisting's with the *Maud* were unsuccessful in reaching the heart of the Arctic. The region of the Arctic Ocean most difficult of access is not around the Pole itself, but, as V. Stefansson has shown, is an area between the Pole and lat.  $80^{\circ}$  N. extending east and west between the meridians of  $120^{\circ}$  W. and  $165^{\circ}$  E. To reach that region there is too much ice for ships and not sufficiently continuous or smooth ice for sledge-travelling. For these reasons Stefansson gives a point in lat.  $83^{\circ} 50'$  N., long.  $160^{\circ}$  W. as the north pole of relative inaccessibility. The east coast of Green-

land is another Arctic region very difficult to approach by sea on account of ice.

In Antarctic seas certain areas appear to be blocked with pack-ice year after year, with the result that the known coast-line of Antarctica shows several long gaps. The two least accessible shores of the continent are the stretch between Charcot and Edward Land south of the Pacific, and the western shore of the Weddell Sea. Pack-ice renders the Weddell Sea particularly difficult and dangerous to penetrate on its western side. On account of winds and currents the ice is generally driven towards the west, and the pressure is eased only by a slow north-westerly drift. There is probably no more dangerous sea in polar regions than the Weddell Sea. Of the five vessels that have reached high latitudes in that sea, the *Endurance* was crushed and sunk, the *Deutschland* was caught and drifted several months, and the *Scotia* was beset but escaped by a miracle in which skilful handling played a great part. Weddell's two vessels were the only ones to meet no difficulties with ice, a stroke of luck that must be very rare in that sea (p. 97).

The landlocked Arctic Ocean, with comparatively little movement in its pack, except towards the Greenland Sea, is far safer for ice travelling than the Antarctic. In the latter the pack-ice faces an open ocean and even along the coast fast-ice seldom stays long in position. The floes are liable to drift toward the open ocean under the influence of the frequent off-shore winds, and the explorer trusting to the sea-ice might find himself swept to destruction with little or no hope of escape.

Pack-ice is destroyed only when it drifts into relatively warm seas. Surface melting due to summer sun is not unusual in the Arctic but is rare in the Antarctic, where pools scarcely ever occur in the floes. It is facilitated by the presence of rock dust blown on to the ice. Floes on the outer fringe of the pack are liable to be broken into small pieces by ocean swell. These larger or smaller pieces of ice, and they may remain relatively large, have their temperature raised to freezing-point and then disintegration is rapid, for the floe becomes soft and friable. The small pieces quickly melt. Partial or local melting in a floe would produce a honeycombed effect, which is unusual. For this reason it seems likely that the melting is uniform and relatively rapid, but the part

played by mechanical erosion is important and not to be neglected. The wreckage of the pack on the edge of polar seas is known as brash and forms little impediment to any vessel, although a heavy and relatively fresh bit of floeberg or growler coming in contact with a propeller might easily cause a blade to snap.

Sea water, unlike fresh water, is at its maximum density at freezing-point, but all ice expands at the moment of formation and therefore floats. Moreover sea-ice is not, strictly speaking, frozen sea water, because the freezing is a selective process in which most of the saline matter is discarded, the ice thus being practically fresh. The mother liquor, with its increased content of salts, sinks by reason of its greater density: the ice floats. Sea-ice being permeable contains occluded brine, and on this depends its varying salinity. Quick growth means much trapping of brine globules and so high salinity. Drainage results in loss of brine, and so lower salinity. When floes are ridged up they drain rapidly through the capillary spaces. Old floes and hummocks are thus practically fresh, and are frequently used by explorers as a source of drinking water. In the process of drainage the ice loses plasticity and becomes harder and more brittle, characteristics which help to make the "fresh" hummocks recognizable.

The longer this drainage continues the more the ice changes its appearance, until eventually it acquires a granular look and is difficult to distinguish from glacier ice. This is the kind of sea-ice which the Eskimo call *sikûssaq*, or very old ice. The older the *sikûssaq* the rougher is its surface, and according to L. Koch, no sea-ice merits this name until it is at least twenty-five years old. It is found chiefly in certain fjords on the north-west of Greenland, where the sea-ice is jammed hard against the coast by the pressure from the sweep of the current across the polar basin.

Terms used in the description of sea-ice came originally from the whalers, than whom no one was more conversant with the ways of ice. The chief terms, with their definitions, are as follows:—

Bay-ice—unbroken, undisturbed floes, not necessarily *in situ* along the coast.

Bergy bit—small growler.

Black ice—transparent homogeneous ice, appearing black, due to the freezing of fresh water pools on pack-ice.

Brash—wreckage of pack-ice.

Drift—very open pack-ice that offers no impediment to navigation in any direction.

Fast-ice—ice which remains in place of growth along the coast for a winter or longer.

Field—an apparently limitless area of floes or floe.

Floe—an area of ice, large or small, but not fast.

Frazil—fine spicular crystals and ice-flakes not built together into a sheet. A term from Canadian river ice, not used by whalers.

Growlers—small pieces of berg or pack floating almost awash.

Hummock—a ridge or elevation on a floe due to pressure.

Ice-blink—the white reflection in the sky beyond the horizon which signifies the presence of close pack.

Icefoot—a rim or shelf of ice, or consolidated snow, adhering to the coast, unmoved by tides and remaining for some time after the sea-ice has moved away. Not to be confused with ice-tongue or shelf-ice, originating from spread of glaciers.

Lane or lead—a water passage among floes.

Pack-ice—floes of various ages and ruggedness, generally with a considerable snow covering: may be close or tight with no intervening water visible or open, with lanes and pools of water between the floes.

Palæocrystic—old heavily hummocked snow-covered ice, occasionally mixed with glacier ice. Not a whaler's term: introduced by Nares in 1876. According to L. Koch the same as the Eskimo's sikûssaq, which, however, is wholly sea-ice.

Pancake-ice—small circular pieces of new soft ice or semi-consolidated snow and water.

Rubber-ice—an expressive American term for new thin sea-ice without rigidity, which yields to the weight of men and sledges and may give way.

Tide cracks—single, double or more complex cracks rough parallel to and near the shore between the ice-foot (as it eventually will be) and the main body of pack rising and falling with the tide.

## CHAPTER VII

### THE ARCTIC OCEAN: BASIN AND COASTS

**T**HE land-locked sea around the North Pole may be regarded as a mediterranean sea or, from another standpoint, as a gigantic gulf or border sea of the Atlantic with which its surface waters freely communicate. But it has peculiarities of position, circulation, physical condition and tides which give it distinctive characters, and its deeper layers are entirely cut off from those of the Atlantic and Pacific. Thus it receives the rank of an ocean although its size is about 5,400,000 square miles or approximately one-sixth of the area of the Atlantic or nearly six times the area of the Mediterranean Sea.

It consists of a relatively small north polar basin, probably little over 2,000 fathoms in depth, lying eccentric to the Pole with its greatest extent towards Alaska and Eastern Siberia, surrounded by a wide continental shelf of less than 100 fathoms, on which lies many islands and groups of islands, especially numerous to the north of America. The uniformity of this wide shelf is interrupted by several depressions. The first is Baffin Bay, between Greenland and Baffin Island, where over a small area the depths fall to more than 1,000 fathoms; the second is the great area of the Greenland Sea (occasionally but incorrectly known as the Norwegian Sea), where over a wide extent there are depths of more than 1,600 and even 2,000 fathoms; and the third is the shallow Barents Sea, which is really a gulf of the Greenland Sea, nowhere deeper than 250 fathoms and in most parts much shallower. The Kara Sea is the name of a semi-landlocked area of shallow water on the shelf between Novaya Zemlya and the Yamal peninsula. Beaufort Sea applies to that land-free corner of the Arctic Ocean that lies between Alaska and the Canadian Arctic Archipelago. Other parts of the ocean receive local

names that convenience justifies but which do not indicate physical distinctions. The Bering Sea, to the south of Bering Strait, is outside the Arctic Ocean. The exact extent of the deep polar basin is not yet charted, but the deepest soundings, a little over 2,000 fathoms, have been taken on the Asiatic side in about lat.  $85^{\circ}$  N. Peary reported a sounding of 1,500 fathoms, no bottom within 5 miles of the Pole, and Amundsen found a depth of 2,050 fathoms in a single sounding to the north of Spitsbergen about 137 miles from the Pole. On the American side there is a depth of 2,500 fathoms within 90 miles of Alaska, but only 274 fathoms about 100 miles north west of Isachsen Island. The evidence was entirely in favour of a land-free polar basin over the unexplored areas of the north, even before Amundsen made his transpolar flight and found no land. A so-called "polar continent" is out of the question and has been suggested only by theorists, who could neither read the evidence nor appreciate the scale of a map. Even small islands beyond the limits of the continental shelf off Greenland, Ellesmere Island and the Parry Islands, are most improbable.<sup>1</sup>

The deep basin of the Greenland Sea is apparently cut off from the polar basin by a ridge at about 1,500 fathoms between Spitsbergen and Greenland, but more soundings are required before the extent of the ridge can be accurately defined. On the south the Faroe-Icelandic or Wyville-Thompson ridge at less than 500 fathoms separates the basin of the Greenland Sea from the deeper waters of the Atlantic and prevents the deep polar water finding its way south (p. 81). The Greenland Sea, however, affords the only wide and relatively deep outlet of the Arctic Ocean. Other outlets are shallow and narrow, including Bering Strait, which is only 36 miles wide and 30 fathoms deep, and the several shallow outlets through the Canadian Arctic islands, of which Smith Sound is perhaps the most important. It is only near Alaska that the 100-fathom line approaches the mainland coasts of the Arctic Ocean: elsewhere it is far to the north. Extensive submergence would appear to have thus extended considerably the

<sup>1</sup> The tidal observations of the recent *Maud* expedition confirm this disbelief in land in the heart of the Arctic Ocean, a conclusion which H. H. Sverdrup reached in 1924.

area of the Arctic Ocean beyond the deeper and older polar basin. Evidence of submergence on a large scale can be found in the separation of Spitsbergen and Novaya Zemlya from Europe and in the submarine configuration of the Barents Sea which bears all the features of a river-eroded plateau.

The origin of the Arctic Ocean as an earth feature is not clear. It lacks, as far as is known for certain, any relatively shallow central part and sagging margins, yet round a considerable extent of its circumference there is evidence of geosynclines and folding. The Mesozoic Caledonian folds touch its Atlantic side, extending from Highland Scotland through Scandinavia, Bear Island, western Spitsbergen and northern Greenland to Grinnell Land (Albert and Victoria Mountains). And O. Holtedahl traces a Pacific-Arctic geosynclinal system through the Permian folds of Novaya Zemlya from the Urals eastward along the Arctic coast of Siberia and its islands into Alaska. The folds associated with these geosynclines have been much worn down, and this is not surprising in view of the great activity of weathering agencies in the unglaciated lands in the present Arctic climate. The existence of these belts of weakness in the earth's crust is further suggested by the zone of vulcanism which extends through the de Long, New Siberian and Franz Josef Islands to Spitsbergen. If this reading of the evidence is correct, it follows that land probably occurred on either side of the geosyncline in comparatively recent geological times, or, in other words, that the Arctic Ocean is a relatively new feature on the earth's crust. Holtedahl's examination of the Palæozoic faunas of Arctic lands show that they were shallow water faunas and that the Arctic basin did not exist in Palæozoic times.

Further, if the folding of marginal zones of the ocean is, as it may well be, due to isostatic adjustment to the sinking of the loaded continental shelf and the oceanic floor, the lack of high folds round the Arctic basin might reasonably be adduced as a further argument of its relative youth.

The problem is certainly a complex one and incapable of solution in the present state of knowledge, although there is a probability that the Arctic basin is radically different from the Pacific in its mode of origin. It might at the same time be added that if the somewhat discredited tetrahedral

theory be accepted the Arctic basin falls naturally on one of the sides of the tetrahedron, and the circumpolar foldings agree very roughly with the edges of that face. The theories with regard to the shape and origin of the earth are outside the scope of this work.

This explanation of the origin of the Arctic Ocean would seem to dispose of Wegener's idea of a movement of Eurasia, and to a less degree America, away from the Pole, combined with a westerly movement of Greenland and Spitsbergen. If this movement had taken place it would certainly widen the Arctic basin by a separation of land areas formerly united, but it would have produced the folds, not in the rear, but in the van, of the moving lands. Spitsbergen alone shows this folding on the western side. The only evidence that could support the displacement theory is the probability of a line of fissuring marked by the basaltic flows that are characteristic of the islands north of Eurasia.

The remarkable width of the continental shelf in Arctic regions, especially around the Arctic Ocean, requires some explanation. Nansen has argued, on evidence that leaves little room for doubt, that the continental shelf is to a large extent a plain of marine abrasion. Otherwise it would be difficult to explain its striking relation to the shape of the present coast and the nature of its rocks. The topographical features of the shelf are frequently continuations of the features of the coast lands. On the continental shelf waste from the land has been deposited chiefly in the hollows: elsewhere it tends to be swept away by tidal and other currents to the greater depths of the continental slope. Marine denudation has been a powerful factor in cutting the shelf out of the continental land, but has been helped to a great degree by the disintegrating power of frost which is an active agent of destruction on all Arctic coasts. Hence the shelf is best developed around those seas where climate has assisted the action of the sea.

The process is obviously a slow one, and as a result the continental shelf must be looked upon as mainly pre-glacial in origin. The deposits of land waste on its surface, though limited largely to the hollows, are enough to press it down into the isostatic layer to an appreciable extent. It is also

possible that the great width of the continental shelf is deceptive, to the extent that the land waste washed off the shelf on to the continental slope, piles up beyond the edge of the shelf and so adds to its apparent width. Some of the soundings believed to be on the shelf may really be beyond the rocky platform.

If, as seems probable, the continental shelf is a plain of marine abrasion it must at one time have been higher and the sea lower than at present. In other words, there must have been changes in the relative altitude of sea and land since the development of the shelf. Its outer edge must at one time have been at sea-level or the waves could not have done their work.

There can be no doubt that the development of the gigantic Pleistocene ice-caps reduced the general level of the oceans throughout the world by the abstraction of great quantities of water. Nansen has calculated that, on a basis of the ice-caps averaging 3,280 feet (1,000 metres) in thickness, the level of the Pleistocene oceans was 430 feet below present sea-level: E. von Drygalski put the reduction in level at practically 500 feet. Other estimates reduce the ocean level by less, such as A. Penck's 130 feet and R. A. Daly's 220 feet, but in any case there certainly was a considerable reduction.

Contemporaneously with the reduction in the level of the sea there was a reduction in the level of the land owing to an isostatic adjustment to the weight of the ice-caps. This was greatest inland where the mass of ice was located and probably caused an upheaval of the continental margins, both emerged and submerged. The sinking of the land may have been as much or more than 330 feet, and this may well have caused a marginal upheaval of some 160 feet. Thus the level of the sea relative to the land would have been 600 to 650 feet lower. The continental shelf was certainly above sea-level in these times and was probably subjected to river denudation, of which it bears evidence in places for part of that period. But during the time of the maximum extension of the ice-caps the shelf must have been covered by glaciers or the thin edges of the ice, which would protect it from wave action.

With the melting of the ice-caps and the return of the

water to the oceans, the land fell and the ocean level rose. It follows then that the period during which the continental shelf was actually exposed to wave action was much too short for wave and frost action to cut wide platforms. Another explanation must be found to account for the changes in sea-level that must have occurred in connection with its formation.

Nansen finds the cause of these changes in the deposition of sediment in the sea. The sequence of probable events is intricate and can be indicated only qualitatively and on broad lines. Sediments poured on to the sea-floor depress it by their weight. This depression is more or less balanced by a rise in level of the sea owing to the filling of the ocean basin. But the depression of the sea-floor causes an upheaval of the coastal lands by way of compensation, and this upheaval is intensified in the continental borders by the action of denudation in removing material from the land. On the shelf, however, there is no elevation since the waste both from the coast and the interior of the land is adding to its weight ; it is therefore pre-eminently a region of depression. Depression assists the action of the waves in exposing fresh shore surface and allowing the abraded waste to lie below the level of the surface waters, and to not impede their power of destructive work. The gradually increasing depth of water also means added weight and so depression of the coastal shelf. Nansen points out that without an initial submerged border to the continental surface, the formation of a shelf would be much impeded, and thus it is that broad shelves are found along low and gently sloping coasts.

Another feature characteristic of Arctic shores which has a somewhat similar origin is strandflat or coast platform. It is not confined to the Arctic, but is peculiar to coasts of lands that have been or are heavily glaciated. In fact it was first described as a feature of the coasts of Norway. The strandflat is a rocky platform of varying width, by no means level or uniform in appearance, and generally cut by arms of the sea into islands and peninsulas. In addition to the Norwegian coasts where it is absent only in Finmarken and in the south, it occurs on the Arctic coast of Siberia, is well developed in Novaya Zemlya, Spitsbergen and Bear Island, on the west, but doubtfully on the east, coast of Greenland, in

the Canadian Arctic islands and the islands off the Alaskan coast. Its mean level is about 100 feet above sea-level, but it varies a little. In Norway a lower strandflat is found at an altitude of 50 to 60 feet, and both in Norway and Spitsbergen there is a well-developed submerged strandflat at less than 30 feet depth in Norway and less than 65 feet in Spitsbergen. Closer exploration of other Arctic coasts will probably reveal this submerged platform which accumulating evidence already suggests. In Spitsbergen the main strandflat is particularly level and forms extensive areas of plains, the only ones in the islands, like the Foreland Laichs, Dieset plain and Reindeer Land. Up the fjords it is less well marked than on the coasts, but its occurrence in places is clear proof that it must have been formed later than the fjords. As a rule it is marked off clearly from the elevated land of the interior which rises from it abruptly, but there are many places where screes of recent origin obscure the junction. This strandflat is not to be confused with raised beaches of loose material, a number of which mark temporary levels of the sea in recent times.

It has been proved that the strandflat is not due to faulting, since its surface often continues without a break across dislocations. Moreover in Spitsbergen it has been found in districts where there are no traces of faults, and the surface features are not those of a peneplain as G. de Geer suggests. Nansen sees in the strandflat another plane of marine abrasion in which the action of the waves has been assisted by frost. Its great extent in Spitsbergen is due to the little power of resistance offered to frost by the rocks except in the few regions where crystalline rocks occur: there the strandflat is narrow. It must be post-glacial in origin not only because it was formed after the erosion of the fjords, but also because if it had existed before the time of maximum development of the ice-sheets, it would have been destroyed or at least profoundly modified by the action of the ice. But on the other hand, the presence of erratic blocks and moraine material on its surface in places is a clear indication that it was formed before the last great advance of the glaciers.

The main strandflat is so marked a feature on Arctic coasts that even with the combined action of waves and frost a

considerable time must have been required for the platform to be cut. This necessitated a period of relative stability or isostatic equilibrium. Nansen believes that the Arctic strandflat, and the reference is particularly to Spitsbergen where it has been most studied, was formed during interglacial periods. It was apparently formed when glaciation was less extensive than now, since places are known in Novaya Zemlya as well as Spitsbergen where the strandflat continues underneath existing glaciers, unless the growth of these glaciers is due to purely local causes.

It cannot have been formed at periods when the climate was warm enough to cause the total disappearance of the ice-caps, since frost action, which is a potent factor in its origin, would not then have been available, but it may have been formed when the glacial conditions after a mild period were again setting in and before the ice-caps had assumed great dimensions.

But if the ice-caps were small when the strandflat was formed its present elevation cannot be explained by isostatic adjustment of the level of the land to a decreased load. This assumption, however, is not necessary since there is evidence of the lowering of the level of the ocean. The present height of the strandflat is due to a recession of waters more probably than to an elevation of land. Nansen has calculated that on the assumption that the present ice-caps of Antarctica and Greenland have an average thickness of 3,280 ft. (1,000 metres), they have abstracted from the ocean enough water to lower the general level 124 feet (37.8 metres). The former level of the ocean when these ice-caps did not exist would actually not have been lower by that amount, because the greater weight of the waters would have depressed the floor. He calculates that the net rise in sea-level would have been 82.6 feet (25.2 metres), allowing for the correlated upheaval of the land areas by compensation. This would explain the formation of the strandflat. The submerged strandflat, on a similar line of argument, may well have been formed when the ocean level was much decreased by more extensive ice-caps than now exist. The uniformity in level of the strandflat in many lands agrees with this assumption of a general change in ocean level.

## CHAPTER VIII

### ARCTIC CURRENTS AND ICE

**I**NTO the landlocked Arctic ocean is pouring an immense volume of water from the Mackenzie and the great rivers of Siberia, the Kolima, Lena, Khatanga, Yenisei, Ob and others. Murray has calculated that a land area of 8,600,000 square miles drains into the Arctic Ocean. In the low air temperatures evaporation is slight and is further impeded by the extensive areas of drifting ice, which forms readily in this relatively fresh water. Thus the Arctic Ocean may be regarded as a vessel into which water is always being poured. It must in consequence overflow, and the tendency to overflow is helped by the normal high barometric pressure.

The main outlet is between Spitsbergen and Greenland, *pilestraedet* or Arrow Strait of the sealers, with minor outlets by Bering and Davis Straits. Towards these outlets the Arctic waters are always flowing. The strong wide East Greenland current flows through the main outlet, filling with ice the 300 miles between Greenland and Spitsbergen, but further south restricted to the western side of the Greenland Sea, to which it is deflected by the rotation of the earth.

Currents of similar origin but weaker in strength flow southward along Ellesmere and Baffin Islands and along the Siberian coast of Bering Strait. They are also found on the east coast of Spitsbergen, Franz Josef Land and Novaya Zemlya, thus keeping east coasts blocked with ice for all or most of the year, and washed with cold water. Winds blowing outward from the Arctic high pressure, and particularly from the Greenland high pressure, assist these flows.

Within the polar basin the water moves towards the chief outflow, crossing from Siberia to Greenland. Rotational deflexion swings the main stream clear of the Siberian coast,



FIG. 7.—Arctic Ocean—Currents

and this action is probably assisted by the great outflow of water from the Siberian rivers.

There is some likelihood that this transpolar stream is only part of a general circular flow of waters around the polar basin, a flow which is combined with the steady overflow by the Greenland Sea and other minor outlets. Past the Parry Islands and along Banks Island the current flows south, due probably to some of the Atlantic-seeking waters missing the main outlet being piled up to north of Greenland and finding an outlet towards Alaska. The earth's rotation and the air circulation assist this movement. Evidence is not wanting of westerly and north-westerly drifts of the waters off the north coast of Alaska, as shown by the drift of the icebound *Karluuk* for 1,000 miles in 1913 from Point Barrow to the vicinity of Herald Island. In 1905 a cask intentionally cast adrift six years earlier on Point Barrow, Alaska, was found on the north coast of Iceland. Clearly it had drifted by this current across the polar basin. The exact route is a matter of speculation, and probably it was much the same as that of the *Karluuk* as well as the *Jeannette* and the *Fram* (p. 16), a distance of over 2,500 miles in not more, but possibly much less, than six years.<sup>1</sup>

When the flow is easy the ice is fairly smooth and there are large floes and perhaps lanes of open water. Peary's Big Lead north of Grant Land (Ellesmere Island) in about lat.  $84^{\circ}$  to  $85^{\circ}$  N., extending eastward to Cape Bridgman, suggests, from the little that is known of it, a weakening of the current, and the easterly drift, which he experienced to the north of it, indicates that the bulk of water east of the meridian of long.  $50^{\circ}$  W. is pouring towards the Greenland Sea as the path of least resistance. The pools of open water that Amundsen reported in 1926 in the vicinity of the Pole confirm this belief. L. Koch reports a westward drift on the north coast of Greenland to the west of Cape Bridgman and an easterly drift to the east of it, and he comments on the hummocky ice where the pressure is against the coast of

<sup>1</sup> Stefansson's and Storkerson's journeys over the ice to the north of Alaska in 1914 and 1918 proved the existence of eddies in the Beaufort Sea with an easterly set some 300 miles north of the coast.

Greenland and Grant Land. On no Arctic coasts is the pack-ice rougher or more difficult to cross.

By this circulation of the waters of the Arctic Ocean the pack-ice is kept in continual motion. Some of it remains in the polar basin but the greater part of it is carried outwards towards the Atlantic. It has been estimated that twenty-six billion cubic yards of sea-ice are annually drifted to lower latitudes.

The East Greenland current, moving at an average rate of six miles an hour and generally keeping to the west of Jan Mayen and Iceland, carries with it pack-ice that may have drifted for five years from the other side of the polar basin. Like all currents it throws off eddies and backwashes which in late winter and spring bring the edge of the ice eastward to an undulating line drawn from the north-west of Spitsbergen to Jan Mayen and thence to the north coast of Iceland. Generally the ice keeps to the west of Iceland, in Denmark Strait, owing to a branch of the warm Irminger current which touches Iceland on the south, and sweeps round the west coast to the north. But there are months in some winters and springs when the pack envelops not only the whole of the north coast but even the east and south coasts of Iceland. South of Denmark Strait the drifting ice quickly melts as the waters of the cold current mix with those of the Irminger Current, a mixing which is promoted by the shallows of Denmark Strait checking the rate of the current from the north. However, a considerable part of the East Greenland current rounds Cape Farewell and continues northward along the west coast of Greenland, carrying with it the "storis" from the east coast.

Relics of the *Jeannette*, personal objects that left no doubt in identification, found on an ice-floe off Julianehaab, in south-west Greenland, were carried by this current from the New Siberian Islands. Recently the driftwood off the same settlement revealed a name board of the *Ragnvald Jarl*, wrecked off the north coast of Spitsbergen, nearly thirty years earlier.

It must be remembered that the rougher and more hummocky is pack-ice, the more resistance does it offer to wind, and that important as currents are in moving ice direct wind

action is even more effective, so that pack may even move, for a time at least, against a prevailing current if a contrary wind is strong enough. Moreover, heavy thick floes or, even more so, large icebergs projecting far below the surface by offering a larger area to wind or current may move at a greater rate than the main body of the pack.

Behind the East Greenland pack-ice there generally lies a belt of coast water from 1 mile to 4 miles wide. E. Mikelsen believes that it extends from about lat.  $77^{\circ} 40' N.$  to Denmark Strait or further south. It marks the westerly edge of the cold current from the north, and tends to be invaded by pack during northerly winds, which are common, but cleared of straying ice by southerly winds. This coast water is thus outside the current, lying in the lee of peninsulas and islands, and divides the polar pack from the ice formed along the land and in the fjords. In June and July it is frequently filled with moving ice, and of course in winter it is frozen.

Westerly winds spread out the East Greenland ice: easterly winds jam it together, make it more impenetrable, and clear the sea to the east. Also it must be remembered that much of the ice in the Greenland Sea in winter and early spring is not current-carried ice but pack formed in the sea itself to the east of the Greenland current by the ready freezing of surface water of low salinity, all the lower by the melting of summer ice and autumn snowfall. In May the ice in some years has extended nearly half across the sea to Norway.

In the course of the summer the belt diminishes and by autumn the coast between Angmagsalik and Scoresby Sound may be clear of ice, but by that time new ice is beginning to form in the bays and fjords. October is the month with least ice on this coast, and it is seldom earlier than July that the coast can be reached.

The cold current round Cape Farewell brings ice (storis) and icebergs in January, and by May there is a belt over 60 miles wide extending northward along the coast to Godthaab. In June this pack begins to dwindle and by August the storis has gone and the whole south-west coast is clear except for a few bergs, and remains clear till January. North of Davis Strait any pack-ice on the Greenland coast, "vestis" or west ice, comes from the western side, but in summer there is none.

Icebergs, however, are released from glaciers and drift out of the fjords in July and August, often hampering safe navigation. Occasionally they are discharged with catastrophic suddenness, due probably to the pressure of great water reservoirs held in crevasses after a period of strong föhn winds.

In the middle of Baffin Bay there is always pack-ice, and it is liable to spread across to Melville Bay. Here the old-time whalers had an anxious time "taking the Bay" on their way to the "North Water," the open waters of Smith Sound, and the "West water" off Baffin Island. Even Kennedy and Robeson Channels may be cleared of ice by strong northerly winds and open water may reach to lat.  $82^{\circ}$  N. in this sea, but with south-westerly winds the channels are blocked with outflowing pack from the north. Long ago there was exploded the theory of an open polar sea, born merely of ignorance and hope, but strangely enough supported by such explorers as E. K. Kane and I. I. Hayes in the middle of last century.

The open "North Water" of Baffin Bay may be due to the winds off the Greenland ice sheet blowing the ice away to the west associated with the presence of warmer water welling up from below, derived from the Davis Strait branch of the Gulf Stream drift, when the easterly winds remove the cold but less saline and so light surface layer.

The Labrador current carrying pack-ice and bergs flows south on the west of Davis Strait along Baffin Island and Labrador. It originates chiefly in Baffin Bay, but receives some water from the Arctic Ocean by Smith Sound and Lancaster Sound. The East Greenland current contributes little to it. May and June mark the culmination of the ice season on the Newfoundland Banks, with the ice reaching as far as lat.  $38^{\circ}$  N., long.  $38^{\circ}$  W. In June the drift decreases, and in December it retracts furthest, reaching on an average not further than lat.  $42^{\circ}$  N., long.  $50^{\circ}$  W.

No ice passes through Bering Strait into the Pacific but a slight cold current takes the western side, the Oya Shivo current which flows into the Kamchatka current and eventually reaches the northern islands of Japan. Ice is found in the Bering Sea in winter and stretches from Alaska to Kamchatka. In May it begins to retreat northward and by August the sea

and straits are clear. Then for two months there is the probability of open water to east and west of the straits, but not always as far north as Wrangel Island, and more often to the east along the Alaskan coast.

Among the ice of the Arctic seas there is practically no river ice except near the mouths of the Siberian rivers. In any case so small is the amount swept into the Arctic Ocean that its proportions compared with sea-ice are negligible: moreover much of it melts in the open inshore waters of the Siberian coast in summer.

Icebergs have only local occurrence because there are few Arctic lands except Greenland and North-East Land that have glaciers sufficiently large and active to produce great bergs. In the heart of the Arctic Ocean icebergs are never seen. Around North-East Land, Franz Josef Land and Novaya Zemlya they are occasionally seen but Greenland waters have most. In both the East Greenland current and the Labrador current they are frequent. Melville Bay is notorious for its bergs. On the Siberian coast bergs are rare except about Nicholas Land. They may be from Nicholas Land itself or have come from North-East Land and Franz Josef Land by being caught in the deep under-current which in its eastward flow is the probable end of the cooled North Cape drift after it has sunk in the eastern side of the Barents Sea. Arctic icebergs seldom measure 200 feet above the water line and are generally much lower and comparatively narrow and short.

As opposed to this overflowing of the polar water there is an inflow of relatively warm and saline Atlantic water thrown eastward by the earth's rotation. The North Atlantic drift or stream carrying the remains of Gulf Stream water across the North Atlantic before the prevailing south-westerly winds, dependent on the Icelandic low pressure system, sends a branch northward which sweeps past Cape Farewell and washes the south-west coast of Greenland. This warm water flows over the dying southern end of the East Greenland current, but picks up at times a little ice and helping to melt it, carries it northward, occasionally as far as lat.  $64^{\circ}$  N.

Another eddy of the North Atlantic drift turns north-westward as the Irminger current and washes the coasts of southern Iceland, while the main stream sweeps on to the

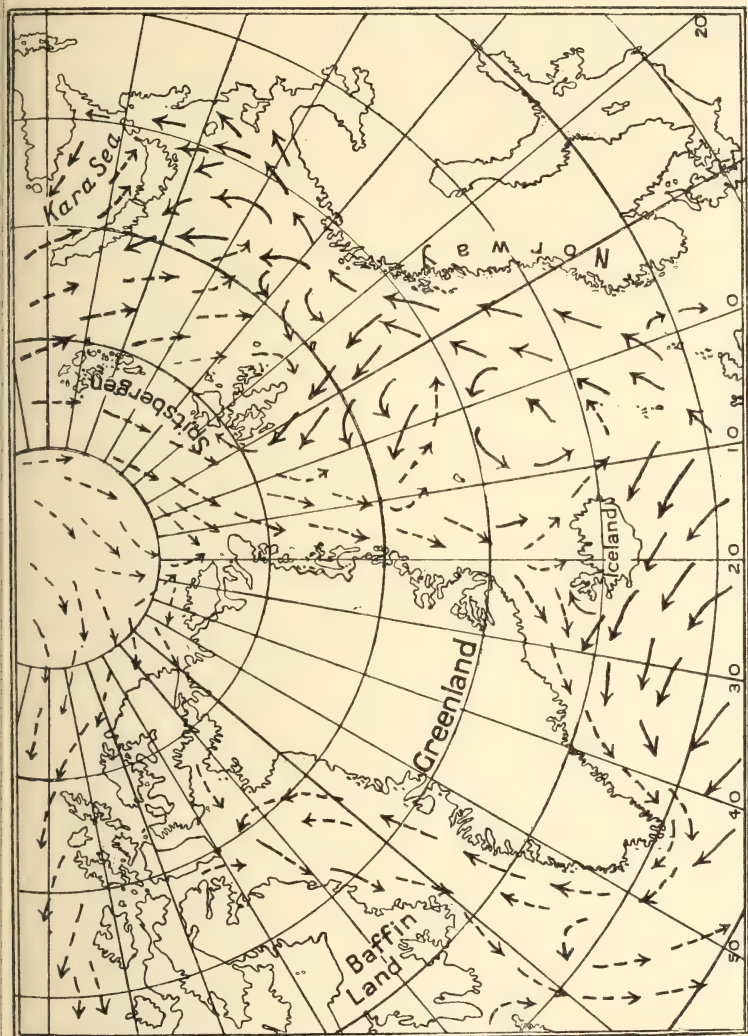


FIG. 8.—Currents in Davis Strait, Greenland, Barents and Kara Seas

coasts of Europe. There it divides, one arm turning south, the other north. The northern branch flows along the coasts of Norway, sending eddies or backwashes into the Greenland Sea, and then, off the north of Norway, divides. One branch as the North Cape drift sweeps along the southern parts of the Barents Sea, keeping its waters free from pack and harbours open in Arctic Norway and the Murman Coast. By the time it touches Novaya Zemlya its waters have cooled and become denser, and, owing to their higher salinity, have sunk beneath the lighter waters of the Arctic Ocean. The other northern branch of the Atlantic drift flows north, as the Spitsbergen drift, past Bear Island along the western shores of Spitsbergen. In consequence that coast is largely free from ice all the year round and frequently wrapt in fog. Ice that occurs is derived from the cold current that sweeps south along the east coast of Spitsbergen and makes that coast largely inaccessible even in the height of summer. Ice from this source at times, especially in spring, is caught by the Spitsbergen drift and carried some distance northward.

Towards the north-west of Spitsbergen this warm drift becomes weak and chilled and its saline waters are dense enough to sink beneath the cold but fresher waters setting southward from the trans-polar drift. The north coast of Spitsbergen is sometimes open even as far as North-East Land, but more often it is closed by ice and the pack is never far distant to the north.

Thus the effect of the wide connection of the Atlantic and Arctic Oceans is to introduce gulfs of relatively warm open water on the eastern and southern sides of the Greenland and Barents Seas and areas of cold ice-congested water on the western and northern sides. The areas of the mingling currents, like on the Newfoundland Banks, are regions of eddying streams and frequent fog. Apparently also they are regions much frequented by seals by reason of food resources and resting places afforded by floating ice (p. 131).

The narrow Bering Strait provides no comparable gulf of warmth into Arctic waters, but there seems to be a slight northward flow of water on the American side. The warm Kuro Sivo current, corresponding to the Gulf Stream of the Atlantic, not only gets little admixture of cold water from the north but sends practically no water to the Arctic Seas, with

the result that the coast of North America gains full advantage of its warmth.

It has been shown by L. Breidfuss that the flow of Atlantic water into the polar basin is at its maximum in winter and spring and at its minimum in summer and autumn. This periodicity he attributes to fluctuations in the flow of the Gulf Stream, which in its turn depends largely on the strength of the north-east trade winds. Thus there is a causal connection between the sub-tropical anticyclone in the North Atlantic and the strength of Arctic currents. The higher the sub-tropical anticyclone, the lower, as J. Hann has shown, is the Icelandic low pressure, and in consequence the stronger are south-westerly air currents that carry the surface waters across the North Atlantic.

The shallow Faroe-Icelandic or Wyville Thompson ridge has a marked effect on the distribution of temperature and density in North Atlantic waters. To the north and south of it there is little variation down to its level, but at 3,000 feet, there is a temperature of  $45^{\circ}$  F. on the south and  $32^{\circ}$  on the north. In other words, the outflow of deep cold water from the Arctic basin is checked by this ridge, thus to some extent checking the fall of temperature in North Atlantic waters.

The area covered with pack-ice in the seas adjoining the polar basins varies considerably year by year. The main movements of the ice remain the same but there are wide variations in the extent and width of the streams of pack, dependent no doubt on variations in the strength of the currents. In recent years the east Greenland current has carried relatively little old ice and the width of its ice belt in 1925 was narrow, suggesting that for some reason the inner parts of the Arctic Ocean are becoming congested with old ice, a state of affairs which would no doubt lead to rafting and piling of the pack and produce such rough ice as Amundsen found 147 miles from the Pole in 1925. From their yearly record of the state of ice in Arctic Seas the Danish Meteorological Institute has computed the ice-covered area in several years. Observations refer mainly to the summer months: lack of ships in those seas precludes data for the winter. In the Greenland Sea the mean area covered with ice from April to August inclusive (1877-1915) is calculated at 342,000 square

miles, while occasionally it fell as low as 270,000 or rises to 424,000. In the Barents Sea it varied from 379,000 square miles to 200,000, with a mean of 294,000 (1895-1915). These and other data suggest that good ice years, like bad ice years, come in groups. In the Barents Sea and Spitsbergen waters a ten to eleven year period has been observed correlated in all probability with distinct variations in the strength and temperature of the warm Atlantic drifts passing into the polar basin. There is not a sufficiently long range of observations to warrant the suggestion of decided change either to or from more icy conditions. It may be that the eleven year periods mark oscillations on a progressive change in one or other direction, but that is not proved. Certainly in Spitsbergen waters there is no evidence of this kind during the last half-century, when observations have been numerous and fairly precise.

## CHAPTER IX

### THE ANTARCTIC CONTINENT

**M**ODERN exploration has established practically beyond doubt that a great continent, placed asymmetrically round the Pole, exists in high southern latitudes. The evidence is in favour of a continent rather than islands in a frozen sea, or even two unequal land masses separated by a strait, but until more than some 5,000 miles of its estimated 14,000 miles of coastline are discovered direct evidence of the continent will be lacking.

Antarctica was estimated by W. S. Bruce to have an area of about 5,400,000 square miles, or about 1.46 times the area of Europe, or 1.8 that of the United States of America. Edgeworth David probably under-estimated the land area of Antarctica in putting it as low as 4,500,000 square miles. Into a roughly circular continent project two great gulfs, the Ross and Weddell Seas, of which the outlines are only approximately known. There are other minor indentations to which it has been found convenient to give specific names, like the seas named Biscoe, Davis, Bellingshausen, although these are only bights of the Southern Ocean, and not well-defined seas. Considerable stretches of the coastline of Antarctica are known : some are mapped in fair detail, others are placed only approximately, and other stretches are hidden by the seaward overflow of the ice-cap. The coasts best known are those of Graham Land and Victoria Land, parts of which have been explored and surveyed in great detail. Less well known are the coasts of Adelie Land, Mary Land, Wilhelm Land and Edward Land,<sup>1</sup> while no landing has been

<sup>1</sup> Royal titles abound in the Antarctic. There is a growing practice to abbreviate them to the personal names in the interests of lucidity and convenience. The curtailment surely does not lessen the honour to the royal persons for whom the features were named.

made on the coasts of Carmen Land, Oates Land, Wilkes Land, Budd's and Knox's Lands, Kemp and Enderby Lands, Coats Land and Charcot Land. The only parts of the interior of which anything is known are Victoria Land and the plateau to the south, George Land and to some extent Graham Land. Great gaps in the known coastline face the Pacific for some 2,000 miles between Graham and Edward Lands, and the Atlantic and Indian Oceans for about 2,700 miles between Coats and Wilhelm Lands except for the isolated landfalls of Enderby and Kemp Lands which have never been revisited. And there are other minor gaps such as 1,000 miles on the western coast of the Weddell Sea and most of the eastern coast of the Ross Sea. As a rule it is due to congestion of pack-ice that these coasts have not been sighted.

In view of the fragmentary knowledge of Antarctica that is at present available it may be asked on what grounds the postulation of an Antarctic continent is justified. The evidence is circumstantial and gathered from various phenomena. No one line of argument carries irrefutable proof, but they all point in the same direction and their cumulative effect is convincing. The following are the main sources of evidence in favour of the continentality of Antarctica.

- (a) The underlying structure of Victoria Land and adjacent regions shows an old plateau of ancient crystalline rocks suggesting one of the old shield lands of the earth's crust. The folded areas of relatively recent crustal disturbances are, as far as is known, confined to the Pacific flank of the plateau.
- (b) Boulders, dropped from icebergs and dredged on the Atlantic side of the Antarctic, are of ancient crystalline rocks and not newer sedimentary strata, thus confirming the continuity of the shield.
- (c) The continuity of land is suggested by the continuity and high elevation of the ice-cap.
- (d) Around the Antarctic regions lies a broad deep sea deposit of blue mud. This deposit is mainly derived from terrigenous waste and is typical of the oceanic borders of all continental lands. It suggests therefore a continuity in the land to the south.
- (e) Certain aspects of distinctiveness in the marine faunas

of the Ross and Weddell Seas suggest no ready means of communication by a strait or straits through Antarctica. Between the faunas of the Weddell and Bellingshausen Seas there are also distinctions.

- (f) Wherever an attempt is made to push a ship southwards in the Antarctic either the land, the seaward edge of a glacier or impenetrable pack-ice is reached. This pack-ice is impenetrable because there is a coast behind it against which it is jammed. The presence of such pack is evidence of continuous coastline in its rear.

Off the mainland important island group occurs around Graham Land, especially the South Shetlands and South Orkneys, which are clear cases of continental islands, and to a less extent off Victoria Land. In the Southern Ocean islands such as South Georgia, the South Sandwich group, Marion, the Crozets, Kerguelen, Heard, Macdonald and Macquarie must be regarded as sub-Antarctic.<sup>1</sup> Several of these as Marion, the Crozets, Heard, Macdonald and Kerguelen are entirely volcanic and probably date from the great Tertiary outpourings of basalt. They may be relics of vaster basaltic flows. The volcanic South Sandwich Islands may be of more recent origin, while South Georgia is of another nature and the remains of a lost land of greater extension (p. 86).

Antarctica is covered almost entirely by a great dome of ice rising from the coasts to interior elevations of some 10,000 feet. This ice-cap completely masks the underlying surface features except for certain mountain ranges that tower above the ice, a few isolated peaks or nunataks near the edge, and in places bare rocks near the coast. In many parts the outflowing ice-cap overrides the coast and projects into the ocean, ending in lofty ice cliffs whence great fragments float away as icebergs. Along all the known coast of Coats Land from lat.  $72^{\circ} 30' S.$  to lat.  $78^{\circ} S.$  no rock has been seen except a few inland nunataks in about  $78^{\circ} S.$  which have not been visited.

<sup>1</sup> Several islands reported at various times can safely be removed from the chart as non-existent. Such are Dougherty Island, the Nimrod Group, Emerald Island, the Royal Company Island, and perhaps Thompson Island. See *Discovery*, April, 1922, and July, 1922.

The structure or build of the continent presents many problems of interest which cannot be solved in the light of present knowledge. Broadly speaking, Graham Land and Victoria Land, the two best explored regions, present striking contrasts and divergent structures.

Graham Land, or West Antarctica as some writers unfortunately prefer to name it, repeats the topography and structure of southern South America. It consists of folded mountain ranges of Mesozoic age, with plutonic exposures, heavily fractured on the north-west and south-east and considerably depressed, so that sea channels lie behind its outer islands. The zones of fracture are associated with present volcanoes, as Deception and Bridgman Islands, and past lava outflows like James Ross Island. The succession of the strata and the petrological character of the volcanic rocks are distinctly Andean. It is impossible to escape the conclusion that these Andes of Graham Land and the Andes of South America must once have been continuous. But the continuity was certainly not across Drake Strait. The line of connection that suggests itself is a great sweeping arc through the South Orkneys, the South Sandwich group and South Georgia. This appears to be one of the hairpin bends that are characteristic of fold mountains in which the middle of the arc is fractured and represented only by widely spaced islands. J. W. Gregory has pointed out that there are difficulties in accepting this theory and has queried the interpretation of the evidence on which various arcs of this nature have been established by Suess and others.

In the case of the Southern Antilles, as this South Atlantic arc has been called, the evidence so far obtained is not conclusive. The rocks of the Powell group (Clarence and Elephant Islands) are too metamorphized to be identifiable, those of the South Orkneys are largely folded Silurian slates and greywackes which do not correspond closely with any other Antarctic rocks, the South Sandwich rocks are apparently all lavas and those of South Georgia are folded greywackes, slates etc., probably of Mesozoic age and not corresponding strictly with any true Antarctic rocks, except perhaps the South Orkney rocks. The strike of the strata in these various groups does not altogether agree with a great Antillean arc. South

Georgia, where the folds, according to Gregory, have no relation to the existing topography, may prove to be the relic of an ancient South Atlantic land. Lastly, the submarine connections as revealed by soundings are too incomplete to give evidence confirmatory of the arc. Yet it is unlikely that the old land connection between Antarctica and America took any other course. Fuller exploration will probably confirm the Antillean theory of Suess.

Victoria Land has been shown to be a plateau bounded along the Ross Sea by a great horst, some 50 to 100 miles wide and rising to 13,000–15,000 feet, which is 2,000–9,000 feet above the surface of the ice-cap. This horst, lying between parallel faults, makes the great mountain ranges of over 1,500 miles along the western side of the Ross Sea and the Great Ice Barrier, which are known in different parts as the Prince Albert Mountains, the Royal Society's Range, the Commonwealth Range and the Queen Maud Range. Transverse faults form great valleys by which the ice-cap flows to the Ross Sea. Folds are absent in the plateau and horst.

Along the eastern fault that bounds the horst can be traced a line of volcanic activity from the Balleny Islands through Cape Adare, Coulman, Franklin and Ross Islands to Mounts Discovery and Morning. Edgeworth David and R. E. Priestley suggested also a line along the western fault of the horst through such mountains as Macintosh and Bowen, with other volcanoes as Mount Melbourne on the transverse fault and a series of volcanic foci where the latter meet the main faults. F. Debenham has shown that this arrangement does not hold in the Ross Archipelago where the numerous volcanoes have a radial arrangement. Yet the main contention holds, that the chief zone of weakness of the horst is associated with volcanic activity.

The horst is capped with horizontal layers of Beacon sandstone, probably of Permo-Carboniferous age. Beneath it is a peneplain of ancient crystalline rocks which appear to underlie the vast plateau on which the ice-cap formed.

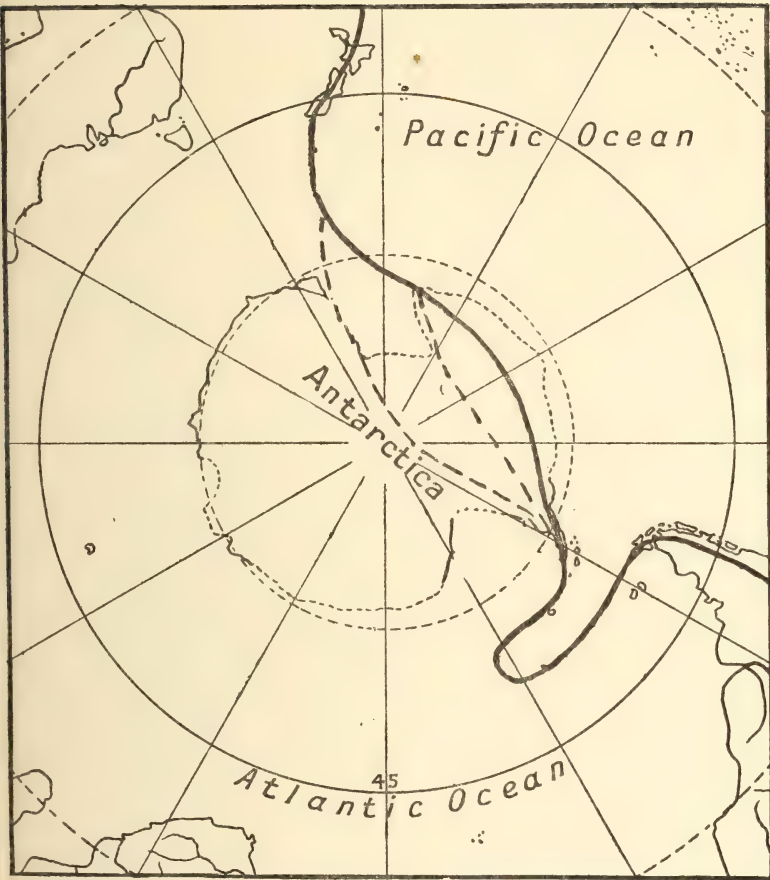
The plateau structure characteristic of Victoria Land has been recognized in Adelie Land and Mary Land. Edward Land, where granite and diorite occur in Scott Nunatak, is probably similar. From Coats Land there is no direct evidence.

The only bare rocks so far reported in that part of Antarctica are several nunataks 15 to 30 miles from the Luitpold coast but they have not been visited. Rock fragments dredged off the coast are mainly granite, basalt and some bits of sandstone which recall the Beacon sandstone so characteristic of Victoria Land. Among the dredgings from the Weddell Sea was found a block of limestone with fossils of Cambrian *Archæocyathiniæ* which prove the existence of old rocks similar to those of Victoria Land in Coats Land or regions adjoining. In all probability Coats Land beneath its ice-cap shows the plateau formation of Victoria Land. Moreover, the narrow continental shelf on the east of the Weddell Sea may indicate that the edge of the land is the faulted edge of the plateau, although no great stress must be laid on this argument.

The relationship of Victoria Land and Wilkes Land generally <sup>1</sup> with land masses beyond the Antarctic is less clear than in the case of Graham Land. There is no evidence of the rocks of the horst having ever been folded, while a study of trend lines suggests strongly that the great faults are continuations of the fault lines of eastern Australia. Petrologically many of the dolerites of Victoria Land are almost identical with those of Tasmania and quite distinctive from those of the Andes. J. W. Gregory suggests that the coastline of Victoria Land is a continuation of that of eastern Australia, a secondary Pacific type of coastline, and that the primary Pacific coastline of New Zealand is continued through Edward Land. With this view the weight of evidence seems to lie, and has received further support in the discovery by J. K. Davis of the Mill Rise, an elongated rocky bank, in 543 to 546 fathoms, lying south of Tasmania.

The relation of the structures of Graham Land with those of Victoria Land is the great problem awaiting solution in Antarctica. It is clear that the Antarctic Andes of Graham Land skirt the Pacific for some distance: they may emerge through

<sup>1</sup> It seems unfortunate that there is a tendency to restrict the name Wilkes Land to a small part of the coastline south of Australia. Of old the name was used in a more general sense, and even if some of Wilkes' landfalls are now discredited his work and priority amply merit the retention of his name for a coastline which otherwise has no general designation.



— Possible course      - - - Less likely alternatives

FIG. 9.—Sketch map to show the possible course of the Antarctic fold lines

Edward Land. In that case the whole Pacific basin, as is not improbable, would prove to be girdled by a series of great earth folds marking a zone of weakness in the earth's crust. But do the Andes of Graham Land send out a south-eastern branch which skirts the Weddell Sea? Probably these do not, since on the eastern side of Graham Land is a low tableland of the Snow Hill region. Moreover, the floor of the south-western part of the Weddell Sea has been found by soundings to be terraced and no doubt faulted, at right angles to the probable coastline. This suggests that the coastline is a fault line across the plateau with submergence to the east. Nothing is known of Coats Land, but vague shapes seen far away by the keenest of the few eyes that have had the chance to look, suggest a lofty interior. Probably the Weddell Sea is bounded east and west by great faults and marks a foundered area of the plateau.

Three solutions have been offered of the problem of the relationships of Graham Land with the plateau which seems to comprise the greater part of Antarctica.

(1) That the Antarctic horst of Victoria Land is continuous with the Graham Land Andes. This view was first suggested by W. S. Bruce and received support from Edgeworth David and D. Mawson. The line of direction of the Maud Mountains, where they are lost to view on the polar plateau, favours this theory. It is not impossible that the line of weakness that resulted in the folding of the Graham Land strata resolved itself in the hard resistant plateau, into a line of great faults. There is evidence on both sides of Graham Land of great faults along which have been lava outflows, while J. G. Andersson has pointed out that the foldings are in the nature of gentle anticlines and synclines. Graham Land with its adjacent islands is in fact what Suess has called a "panzer-horst," in which Edgeworth David sees many resemblances in broad features with the horst of Victoria Land.

(2) That the Victoria horst and the Maud Mountains swing across the Pole to Coats Land and that the Antarctic Andes continue through Edward Land and were once continuous with New Zealand. This means the continuance of the Pacific geo-synclines with their associated folds along the south of that ocean. Coats Land shows no horst like Victoria Land, but

the horst may die down towards the Atlantic. This is A. Penck's view, and he further postulates two unequal land masses divided by an Antarctic strait, of which the Australian end is the Great Ice Barrier. Amundsen's discoveries of land to the south and east of the Ross Sea demolished this strait, which had little evidence in its favour. Even if the strait disappears, however, the suggested relationships of the two sides of Antarctica may be true.

(3) The third theory is a modification of the last, and suggests that the whole of Antarctica, except the Graham Land Andes, is an unfolded plateau; that a great horst crosses this plateau from Victoria Land to the unknown region southwest of the Weddell Sea and that the Andean folds, fringing the Pacific, skirt this plateau and pass north of Edward Land in an arc through some unknown island, or more probably group of small islands, on the way to New Zealand. Such a group of low islands would account for the jamming of the pack to the north of Edward Land and to the east of the Ross Sea.

Future exploration alone can solve these riddles, but it must be exploration of a serious scientific nature.

No discussion of the structure of Antarctica would be complete without reference to Wegener's displacement theory. The central idea in this theory is that the lighter more solid continents float on a dense plastic layer and that they are not stationary in position on the face of the globe. From a single great continental mass the present land masses or continents broke adrift and wandered, the general direction of movement being from poles to equator and from east to west. Thus Africa, India and Australia drifted away from Antarctica while the Americas and Antarctica were drifting westwards. So there was a land bridge between the old and new worlds via Antarctica, which then lay in lower latitudes, as late as Jurassic times, while until Eocene times the connection between Australia and South America was maintained and experienced, in those ages, a climate which would admit of animal migration. Crumbling and folding of the strata along the front of the moving continent explains the folded ranges of the Antarctic Andes and the Southern Antilles. The theory explains the lack of folding in the rear.

This is not the place to discuss the probability or the reverse

of this fascinating theory. Direct evidence is lacking even if many facts are easily explained by its acceptance. Its value is evident in accounting for climatic changes or apparent climatic changes since an acceptance of the theory admits a shifting of the poles on the earth's surface without insistence on a change in the earth's axis from time to time. C. S. Wright and R. E. Priestley have pointed out that through the geological ages "glacial conditions have been the exception and not the rule in Antarctica," and that the great ice sheet did not reach its maximum extension until Pliocene and Pleistocene times. This accords with Wegener's suggestion that Antarctica was in comparatively temperate latitudes until Eocene times. Lastly, many problems in the geographical distribution of animals and plants find a more plausible solution in terms of this theory than by the postulation of *ad hoc* land-bridges, which strain geological faith, to account for discontinuity in areas of distribution.

In surveys of the Antarctic continent no geodetic measurements have yet been undertaken. It is very desirable that surveys of this nature should be made in high southern latitudes as they have been made in high northern latitudes in Spitsbergen. F. Debenham has pointed out the possibility of measuring an arc of meridian in Victoria Land where the existence of suitable land, off-shore islands and the extraordinary clearness of the Antarctic atmosphere should all facilitate the work. He sketches a plan of triangulation extending from McMurdo Sound in about lat.  $78^{\circ}$  S. northwards to Coulman Island in about lat.  $73^{\circ} 30'$  S. The only difficulty, as in so many schemes of exploration, is expense, but sooner or later the work will have to be done. Meanwhile the gravity observations undertaken by a few expeditions have supplied some useful data bearing on the shape of the earth.

## CHAPTER X

### THE ANTARCTIC OCEAN : CURRENTS AND ICE

**T**HE Antarctic or Southern Ocean is a convenient term for the southern parts of the Atlantic, Pacific, and Indian Oceans. The use of the term must not be taken to imply that this ocean has a distinctive basin or is in any way one of the major relief features of the globe. The oceanography of the great oceans cannot be considered apart from their southern extension, of which the use of the term Southern Ocean would seem to rob them. Yet there is a convenience in the acceptance of the term that overrides any objection that can be taken to it on strictly scientific grounds. The Southern Ocean is defined by the Admiralty, in agreement with the governments of South Africa and the Australian Commonwealth, as that ocean bounded on the north by a line joining the southern portions of South America, South Africa, Australia and New Zealand, and on the south by the Antarctic continent. These limits comprise some 8,000,000 square miles of ocean which have many characteristic features contrasting with those of the waters farther north. Obviously the boundaries must be regarded as elastic. There is no merit except convenience in the line defined above. W. S. Bruce defined the Antarctic Ocean as the seas bounded on the north by the average limit of drifting ice, thus giving a boundary which has the merit of not being wholly arbitrary. The average limits coincide roughly with the parallel of lat.  $50^{\circ}$  S. but go to lat.  $57^{\circ}$  S. in the Cape Horn seas, and to north of lat.  $40^{\circ}$  S. in the South Atlantic.

Soundings are few in many parts, but sufficient in number to indicate the broad features of submarine relief. From the coasts of Antarctica, as far as they are known, the sea-floor falls comparatively steeply to 1,000 fathoms. The continental shelf, under 100 fathoms, seems to be narrow, and

the only considerable area of shallow water to be in the Ross Sea, most of which is under 500 fathoms. The basins of the Atlantic, Pacific, and Indian Oceans carry the 2,000 and 3,000 fathom lines a short distance within the Antarctic Ocean, and far enough south in the case of the former to embrace almost the whole of the Weddell Sea. The only "deep," or area over 3,000 fathoms, which invades the Antarctic Ocean is the Ross deep (sometimes wrongly called the Valdivia deep<sup>1</sup>) which lies south of Africa between long. 20° W. and 40° E. Its extent is largely guesswork beyond a few soundings by the *Valdivia* and the *Scotia*.

Among the most striking results of Antarctic soundings are the discovery of shallow water connections with the other continents of the southern hemisphere. There are indications, almost amounting to a certainty, of a shallow ridge between the folded and faulted mountains of South America and those of Graham Land in a long sweeping curve through South Georgia, the South Sandwich Group, the South Orkneys and South Shetlands, with the deep Pacific basin extending eastward through Drake Strait into the Atlantic as far as this ridge (p. 86). There is less certain evidence of the connection of the mid-Atlantic ridge and its southern extension, the Scotia ridge, with this sweeping curve. Deeper but comparatively shallow water lies between the Antarctic continent and New Zealand and Australia.

Many Antarctic expeditions in their hurry to reach their southern bases have paid little attention to oceanographical work in their passages through the Southern Ocean. No waters in the world present greater difficulties for such work owing to their storminess and floating ice, but nowhere is deep-sea work more necessary. Beyond local work in comparatively shallow water the chief researches have been done by the *Scotia*, *Antarctic*, *Aurora*, *Endurance* and *Deutschland*, and in lower latitudes by the *Challenger*, *Valdivia* and *Meteor*.

The surface currents of the Southern Ocean are few and

<sup>1</sup> Ross's original sounding of 4,000 fathoms no bottom in 68° 32' S., 12° 49' W., was proved erroneous by Bruce's sounding, within two miles, of 2,660 fathoms. This position is thus outside the deep, but there is no reason why Ross's pioneer work should not be perpetuated in the original name of the deep.

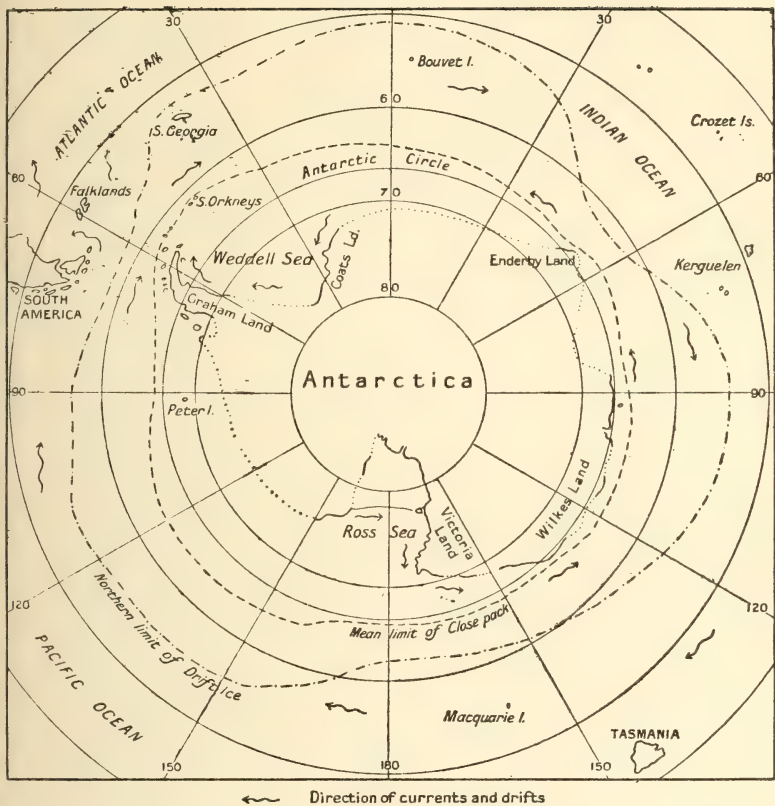


FIG. 10.—Antarctic Seas: Currents and Ice

Note: Icebergs may drift north of drift ice

simple. Prevailing mild westerly winds blowing into the low pressure area that borders the seas beyond the Antarctic continent cause a steady strong westerly drift that encircles the globe between lat.  $35^{\circ}$  and  $60^{\circ}$  S. By the use of drift bottles from the *Scotia* it was shown by Bruce that this drift moves at not less than 10 miles a day. Its tendency to deflect to the left is accentuated by the southern extremities of continental lands lying athwart it. Thus cold currents set northward as the Peruvian, Benguela and West Australian streams. In the shelter from the onward sweep afforded by southern South America, the stream of the westerly drift spreads widely to both sides of the Falkland Islands, and may carry ice as far north as the latitude of  $30^{\circ}$  N. The cold southerly air currents from Antarctica pass with high velocity into the Southern Ocean. They chill the water near the continent and promote its freezing. They also cause an easterly drift near the edges of the continent which jams the ice against any northward projections of the land or ice-cap, and fills with pack any deep bights, especially on their western sides. Eventually, however, the tendency is for the pack to be carried into the westerly drift and in those relatively warm waters it soon rots and melts. The general westward sweep of the pack at some distance from the continent would be stronger than it is if two tendencies were not at work. First, the southerly winds, though generally fierce, cease fairly abruptly near the edge of the continent, far beyond which their influence is rarely felt; and secondly, the westerlies generally have a northerly component which pushes the ice back against the Antarctic coast. Wind and swell together prevent the ice spreading northward and girdle the coasts with impenetrable pack.

This system of currents leads to the accumulation of pack-ice and bergs in certain parts of the Southern Ocean although any water south of lat.  $58^{\circ}$  S. may carry ice in quantities. R. C. Mossman has shown that the northern extension of Graham Land carries high atmospheric pressure between two areas, east and west, of relatively low pressure, the one over the so-called Bellingshausen Sea and the other over the great bight of the Weddell Sea. This leads to a cyclonic circulation of winds in those two areas. As a result the pack tends to clear from the Pacific side of Graham Land and accumulate farther

south in the area between Charcot and Edward Lands, where no ship has penetrated. Similarly the eastern side of the Weddell Sea is relatively clear of ice and often affords an open sea route to the south, as proved by Ross and Bruce and later taken advantage of by Shackleton. On the contrary the western side is so packed with ice that no vessel has been able to reach it. A vessel caught in the pack in the south of the Weddell Sea drifts north in a decided current which does not weaken till in about lat.  $64^{\circ}$  or  $63^{\circ}$  the westerly sweep, clear the north of Graham Land, carries water and ice towards the east again.

In the Ross Sea there is a comparable eddy, the ice lying against the coast of Victoria Land and driving northward before south-westerly winds. Further east lie fairly ice-free waters. Across the mouth, east of Cape Adare, there is generally a broad belt of pack of varying width, due to this circulation combined with the effect of the westerly drift of lower latitudes sweeping the pack backwards and southwards. Thus the *Aurora*, drifting during nine months in 1915-16 in the Ross Sea at a rate that J. M. Wordie estimates at over 7 miles a day, followed the coastline of Victoria and Oates Lands until liberated in the region of westerly winds in about lat.  $64^{\circ} 30' S$ . The congestion of pack on the east of the Ross Sea may be due to obstructions in the shape of islands in the unexplored area north of Edward Land, which has so far proved to be impenetrable (p. 91). The westward trend of the pack feeds the Ross Sea and the calving bergs of the Barrier add to the ice that congests its mouth.

Antarctic seas by contrast with Arctic seas are strewn with great icebergs calved from the enormous ice-cap. No area is free from them even if they collect more commonly in certain regions. Frequently they are tabular, flat and steep sided, and may attain a length of a mile or more. Bergs several miles in length have been measured, and a few of 20 and even 30 miles. A berg of 70 miles has been recorded and one of 82 miles is a more doubtful report. Their height above water is 100 to 160 feet but if tilted by differential melting below they may be higher. These great bergs have sometimes been referred to as ice islands and even mistaken for snow-covered land. In the Ross Sea and on the Pacific side the bergs are

smaller than on the Atlantic side where they are made of highly consolidated ice. O. Nordenskjöld has suggested that Antarctic bergs need not necessarily have their origin on land but can also be built on a base of sea-ice in shallow water near land. It is difficult to accept that theory. These bergs must be looked on as detached fragments of the ice-cap, the larger and very regular ones being probably calved from great ice tongues. A few such bergs are built of snow or stratified *névé*, but 'this kind is far less common than the first Scott expedition reported. Angular bergs of the Arctic type also occur. They are derived either from valley glaciers or from disintegrated tabular bergs. Owing to their size bergs drift beyond pack-ice and have been sighted as far north as lat.  $35^{\circ}$  or even  $26^{\circ}$  in the South Atlantic in midsummer. Off the Rio de la Plata there are numerous records in the Falkland current.

Fifty years ago in her hurried visit to the Southern Ocean the *Challenger* discovered a remarkable feature in the vertical distribution of temperature. Below the cold surface layers at a depth of 50 to 500 fathoms was found a thick layer of appreciably warmer water, under which again the temperature fell to the cold waters characteristic of all ocean floors. Confirmation of this intermediate warm layer was obtained by the *Belgica*, *Scotia*, *Gauss* and *Antarctic*, but more investigations are needed before its extent can be mapped and its origin determined. In all probability it is derived from the surface in lower latitudes in the Southern Ocean and has been drifted southward before the north-westerly winds. Then in spite of its higher temperature it has sunk because of its greater density, due to higher salinity, beneath the cold but relatively fresh and so light waters that are being pushed northward from the coasts of Antarctica by the south-easterly winds. A somewhat similar thermometric gradient has been noted in the Arctic Ocean. At the same time there must be a creeping down the continental shelf and slope of cold water, dense enough to reach and remain on the floors of the great ocean basins throughout the world. This may be the saline surface water cooled as it goes south and thus sunk to greater and greater depths until it reaches the floor of the shelf and then turns northward to the ocean depths. Once its temperature falls its relatively high salinity makes it sink.

## CHAPTER XI

### ICE-SHEETS AND GLACIERS

THE only active remnants of the ice-sheets of the Pleistocene Age are the ice-caps<sup>1</sup> of Antarctica and Greenland. They form the greatest and only completely lifeless deserts on the face of the globe. Owing to their presence the whole Antarctic continent and Greenland are uninhabitable by any form of indigenous life.

An ice-cap is essentially a climatic phenomenon, but, like all glaciers, owes much to topographic influence, since without a suitable gathering ground it could not form. Its most striking feature, however, is the thickness, with which is necessarily associated great area, with the result that all except the more striking irregularities of surface relief of the underlying land are completely masked and not indicated, even in a modified form, on the surface of the ice.

The Antarctic ice-cap, also called the inland ice or continental ice of Antarctica, covers almost the entire area of the continent and in places even flows beyond its edges into the sea. The thickness is a matter of speculation. C. S. Wright and R. E. Priestley give it only 2,000 feet. There is no direct evidence, but since the ice lies on a lofty plateau this estimate may be near the truth. If so, the Antarctic ice-cap is very different from the great Pleistocene ice-sheets of the northern hemisphere, including that of Greenland, which were all of much greater thickness and in several cases spread outwards from a low gathering ground. Its surface is a vast gently undulating plain rising to elevations of about 10,000

<sup>1</sup> No doubt, as J. M. Wordie says (*G.J.*, July, 1921), the terms "ice-cap" and "inland-ice" are the terminology of a previous generation. Scientifically they have been superseded by terms of genetic value, continental, island and highland ice, but ice-cap still has a general if popular usefulness.

feet in the vicinity of the Pole (9,172 feet), and covered with a thin layer of soft snow often blown into small ridges or sastrugi.

The ice-cap is a type of glacier in which the area of deposition, collection or supply is predominant, and the area of wastage, or the dissipation, apart from surface denudation is small. Wastage is largely direct into the sea, and takes the form of abrupt calving of great areas of the ice-cap and their floating off as icebergs. Surface ablation may locally be considerable and even greater than deposition. Adiabatically heated winds from the ice-cap, sublimation of snow and ice and radiation from heated rocks on valley sides and nunataks, are all contributory factors in wastage. The problems of growth are considered on pp. 44-45. Other types of glaciers are associated with the ice-cap. Valley and piedmont glaciers are frequent in Graham and Victoria Lands: in the former because of the small and poor gathering ground in a narrow rugged peninsula which restricts the supply of ice; in the latter, where the ice supply is plentiful, because of the out-flow through the valleys of the elevated horst which fringes the Ross Sea.

A striking characteristic of Antarctic glaciation is the lack of moraines. This is easy to explain. In the first place, since nearly all the continent is ice-covered there can be no surface moraine except from the great lofty ranges; secondly, since nearly all glaciers discharge into the sea, the ground moraine matter is lost to sight beneath the waters.

Not only is the lower end or dissipator of the glacier generally in the sea, but not infrequently long tongues of ice project far out to sea. These in one form or another are the most characteristic of all Antarctic ice forms and are practically unknown in the Arctic. The largest single one so far reported is the Termination Tongue, projecting from the Shackleton Ice-shelf, itself merely a large tongue, on the coast of Mary Land, which stands seaward for about 200 miles.<sup>1</sup> Others, off Victoria Land, are the Drygalski Ice Tongue, 38 miles long, originating in the David glacier, and

<sup>1</sup> The end of the Termination Tongue is certainly afloat, but J. K. Davis believes that so narrow and exposed a tongue of ice could not maintain its position unless resting partly on land.

the Nordenskjöld Ice Tongue, 8 miles long, originating in the Mawson glacier, and the Mertz and Ninnis Tongues off George Land. Soundings show these tongues to be afloat: they rise and fall with the tides, crevasses are few and the sides of the tongues are generally high and steep. As a rule they narrow towards their distal ends by reason of the calving of bergs from their sides. Frequently ice-tongues grow not in sheltered bays where their origin is relatively easy to understand, but stand out into the open sea across strong currents, and despite the solvent action of the sea maintain their positions. Wright and Priestley believe that the occurrence of these tongues in the Antarctic and their absence in the Arctic depends on the lower air and water temperatures in the former than the latter. A very small rise in the temperature of Antarctic seas would suffice to demolish and prevent the growth of these tongues. Even though it is persistent the solvent action of the water must be slow: otherwise by undercutting and consequent collapse, these tongues would break away in bergs and ice-blocks. But persistence in a medium that is melting them, however slowly, is possible only if the rate of forward movement balances the solvent action of the sea. Unfortunately in only one case has any direct measurement of the rate of movement been made; the Mackay Ice Tongue was found in midsummer to be moving forward at a rate of 3 feet a day. It is also possible that the occurrence of these tongues in the Antarctic and their absence in the Arctic is assisted by the more flexible nature of much southern glacier ice. Many Ross Sea bergs lacking the rigidity and steely hardness of Arctic bergs, and for that matter most Weddell Sea bergs, have been termed snow bergs. Tongues of this nature must be yielding and less liable to break than if built of harder ice.

Even more remarkable are the cases in which a number of ice-tongues stretching out as converging fingers have enclosed sea areas between them, the ice on which has become trapped, while eventually tongue and pack alike are snow-covered and merged in a continuous plain. Probably during the greater glaciation of the Antarctic in the past this was a normal occurrence and produced great areas of what is sometimes called shelf-ice. In all probability it is thus that the Ice-Barrier or Ross Barrier was formed.

The Ross Barrier was discovered in 1841 by Sir J. C. Ross who surveyed its northern edge, but no further light was thrown upon its nature until the twentieth century, although in 1900 C. E. Borchgrevink made a few hours' journey, the first ever made, over its surface. L. Bernacchi, who was on that expedition, made the bold suggestion that the Barrier was simply an enormous ice-tongue from the Parry Mountain flowing eastward into the Ross Sea, a theory that probably was not so wide of the mark as it was thought at the time to be.

This great sheet of ice is about 400 miles wide along its seaward edge and over 400 miles from north to south in its widest extent. It covers an area at least equal to that of the British Isles. At its northern edge it is up to 800 feet in thickness and clearly afloat except near Victoria and Edward Lands, but the very slight gradient of the surface suggests that practically the whole of this sheet of ice is floating on the waters of the Ross Sea. It is difficult to establish the rate of northward movement although the Barrier edge has been surveyed in 1841, 1902 and 1911 and found to vary much in position. F. Debenham calculated the rate of forward movement at about 12 feet a day, while C. S. Wright calculates the rate off Minna Bluff on the west side at only a little over 4 feet, but so near the land as 10 miles the speed would certainly be reduced by friction. Any forward growth of the Barrier is balanced or even set back by the breaking away of bergs. From 1841 to 1902 the face broke back 25 miles and then, between 1902 and 1911, it advanced, a short distance on the whole. There is no reason why equilibrium should ever be established between these two tendencies.

The Barrier seems to be due first to the growth of long ice-tongues from the great glaciers of Victoria and Carmen Lands and perhaps other land on the east. Certain mighty glaciers are known such as the Beardmore glacier, the hundred miles of which has no equal on the face of the globe, the Axel Heiberg glacier and others. The tongues date originally from the period of more extensive glaciation. In the land-locked Ross Sea they met and coalesced in places and were elsewhere cemented together by sheets of sea-ice that formed in the gaps. By their weight the ice-tongues spread and flattened while fall after fall of snow eventually gave the whole ice-

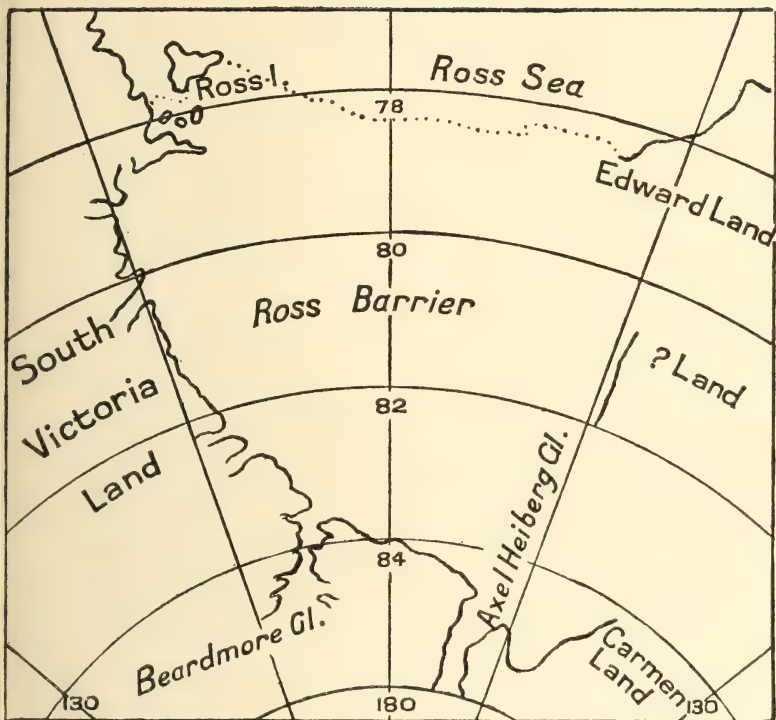


FIG. 11.—Sketch map showing the Ross Barrier and the glaciers, from the plateau, on the west and south

covered sea the levelness of a plain. If the Barrier rested on land the bottom friction would be considerable, the movement slow and there would be inequalities in surface, the ice-covering being much thicker in the vicinity of the feeding glaciers. On the other hand, the apparent lack of thickening near the entry of the glaciers to the Barrier surface suggests that the added bulk in those regions is worn away below, an occurrence that can be due only to the solvent action of water. Hence a further argument in favour of the Barrier being afloat.

That this is the true explanation of the origin of the Barrier cannot be proved though the likelihood is strong. Another possible origin is suggested: that the Barrier was built originally of sea-ice which has been melted by undercurrents as it has been depressed by snow accumulation on the surface, with the result that the present barrier is entirely built of snow congealed *in situ*. This theory presumes that the loss by melting below is less than the gain by snowfall above, or at any rate the two tendencies balance. Otherwise the Barrier would rapidly disappear. But the obvious difficulty in accepting this theory is that it leaves no place for the land-ice which certainly must move down the valleys from the plateau. The Barrier raises many problems of physical rather than geographical interest and for those reference may be made to the results of the expeditions of R. F. Scott, E. H. Shackleton and R. Amundsen.

In the south of the Weddell Sea the Stancomb Wills promontory of Coats Land appears to be built entirely of floating ice, and is probably the remnant of a vast barrier that once filled the southern end of that sea. Its shrunken end is now represented by the Wilhelm or Weddell Barrier which was discovered by W. Filchner in 1912. He found a shattered and unstable area of shelf-ice with a surface level of about 50 feet and evidently afloat, for not only did he observe sea-ice behind it, but some of the barrier actually floated away in his presence.

There is abundant evidence, mainly in the shape of high-level moraines from various parts of the rocky edge of Antarctica, that glaciation has receded to an enormous extent and is probably still receding. The ice-sheet may have been some 2,000 feet and must have been at least several hundred

feet thicker, and ice-free parts of the continent were then almost entirely submerged. Raised beaches indicating an emergence of the land have been found both in Victoria and Graham Lands. In all probability the emergence was due to a readjustment of isostatic balance on the lightening of the load by the shrinking of the ice-sheet.

Erratics, moraine matter, and ice-worn rock at high elevations above the present ice show that it must have stood at a considerably higher level in the past. The evidence points to the ice-sheet having been several hundred, and perhaps several thousand feet, thicker and the ice-free parts of the continent having been almost or entirely submerged. Past glaciation of greater extent is certain, but it must be remembered that flowing ice under pressure can be forced up to great elevations, with the result that traces of ice action may appear far above the general level of the glacier. It is therefore unsound to fix the former thickness from evidence of that nature.

The sub-Antarctic islands of the Southern Ocean lie far from the continent. All show signs of extensive glaciation in the past, and some suggest the presence of ice-sheets that can only have been formed on wider land areas than exist to-day, such as the ice-sheet that appears at one time to have overridden Macquarie Island from west to east. Marion, the Crozets and Macquarie have no glaciers to-day, Kerguelen has a little highland ice or *névé* and a few small glaciers, and South Georgia has many large glaciers.

The purely volcanic nature of most of these islands does not suggest that they once were part of the Antarctic continent, and their distance from the present continent precludes the likelihood of their ever having been overridden by the Antarctic ice-sheet. It is not impossible, however, that volcanic islands like Macquarie, Marion, the Crozets and Kerguelen may, apart from any connection with Antarctica, have had a greater extent in recent geological ages than now, which would under colder conditions allow great ice-sheets to develop. But on the other hand it must not be forgotten that the small island of Bouvet although in as low a latitude as  $54^{\circ} 26' S.$  and with an area of less than 30 square miles is under present conditions nearly completely covered with ice. The present poor

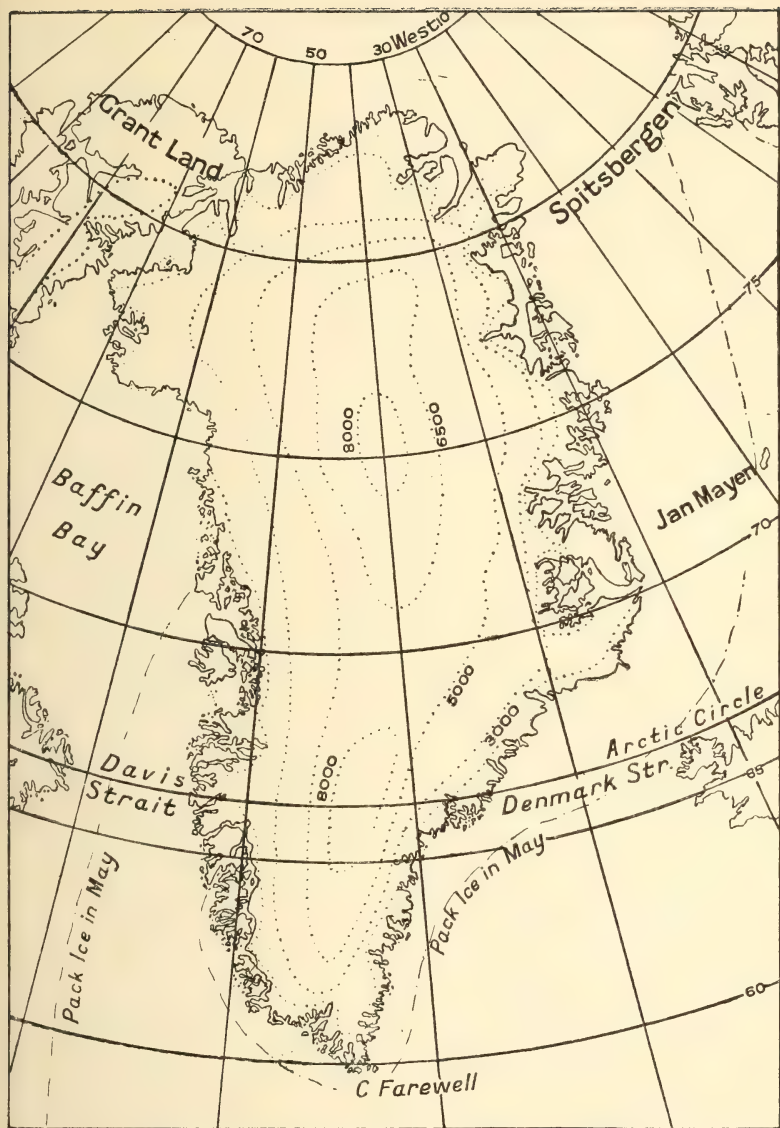
development of glaciation in these islands is due probably to their relatively low altitude which in view of the fairly high temperatures affords no gathering ground for snow. It certainly cannot be due to lack of precipitation. South Georgia, on the other hand, is lofty and rises to over 8,000 feet.

The Greenland ice-cap is the last great relic of the continental ice-caps which during the Pleistocene ice-age covered an area of 6,000,000 square miles in North America and Europe. At the period of maximum glaciation the only ice-free areas in high northern latitudes were probably the northern parts of the Canadian Arctic Archipelago, extreme northern Greenland (northern Peary Land), the greater part of Siberia and perhaps Novaya Zemlya. These lands were free from ice, not because their temperatures were not low, but because, removed from the oceans, their precipitation was deficient.

The Greenland ice-cap is very much smaller than that of Antarctica, covering only about 800,000 square miles. It resembles the southern ice-cap in completely masking the underlying topography of the country and rising to heights of 10,000 feet, but it differs in nowhere overriding the edge of the land or flowing out to sea in a long ice-face.

Practically the entire island of Greenland has a rugged and even mountainous margin, free from ice, varying in width from one or two to over a hundred miles, and in places lofty enough to shut out all view of the inland ice from the coast. The exception to the rocky margin is in Melville Bay where the ice-cap comes down to the coast but does not override many small rocky islets. The ice-free margin includes the whole of Peary Land, that northernmost extremity of Greenland that Peary believed was separated by a channel, afterwards called Peary Channel, from the mainland. M. Erichsen in 1907 discovered the mistake and proved the continuity of Greenland with Peary Land. But in 1921 L. Koch, in finding the deep valley linking Independence Fjord on the east with J. P. Koch Fjord on the west, showed that after all Peary was not greatly at fault. This depression is not below sea-level, but its floor does not rise above 500 feet and contains several long lakes.

On the edge of the ice-cap, where it is relatively thin, bare



..... Approximate contours. Heights in feet

FIG. 12.—Greenland—Ice conditions

rocky peaks here and there stand forth as barren islets : these nunataks cease a few miles from the coast. In places on the west the fjord system of the coast can be traced for 50 miles inland under the ice. But while in places the edges of the ice-sheet are thin, in other places there is a steep and even precipitous margin to the ice. Generally the outer zones are much crevassed and sometimes terraced, leaving long lakes in summer.

The ice-cap discharges by glaciers flowing down valleys into the fjords which dissect the coastal regions. Some fjords are partly filled with glacier tongues, especially on the north-west coast, where the sea-ice packed against the shore prevents the land-ice floating freely away.

The ice-cap defied all attempts to explore it until Nansen crossed its southern end in 1888, Peary its northern end in 1892, and A. de Quervain and J. P. Koch its middle regions in 1912 and 1913 respectively. Rasmussen, E. Mikkelsen and others have since made long journeys over its surface. It has two domes or foci of growth, one in about lat.  $65^{\circ}$  N. that rises to over 8,000 feet and a larger one in lat.  $75^{\circ}$  N. that rises to 10,000 feet. For the rest a gently undulating surface slopes down towards the coast at a gradient which is low in the interior and becomes steeper as the margins are approached. The great heights appear to be nearer the east than the west. This suggests that the underlying rock surface may be higher on the eastern side and that the ice-sheet started on the heights and gradually enveloped the land to east and west. In that case it is probably not more than 1,000 feet in thickness. The older idea, that Greenland is a trough, postulates a much thicker sheet, one of perhaps 6,000 or 7,000 feet, thus approximating to the other great ice-sheets of North America and Europe which were about 10,000 feet in thickness. But the origin of an ice-sheet in a trough is difficult to explain since precipitation would be slight after the inblowing winds had been robbed of their moisture by the lofty mountain rims.

The annual accretion of snow in the interior of the present ice-cap has been estimated, both in north and south, at about 12 or 13 inches of water equivalent and on the margins about 3 feet. This can scarcely be enough to maintain the volume of the ice-cap and still less to have caused its growth (cf.

Antarctica, pp. 44-45). However, de Quervain, basing his estimates on observations taken further south, believes that the outflow of the ice balances the loss by marginal ablation and melting, and that the ice-sheet is not losing ground. He found that the summer melting was little at 30 miles from the coast and practically ceased at 60 miles, but that on the edges it was considerable. This implies a considerable accretion in the interior if the ice-sheet is not shrinking. Conditions near the Arctic Circle where Greenland is less than 500 miles wide may reasonably differ in greater precipitation and greater melting than those farther north. L. Koch believes that the edge of the ice-sheet is now practically stationary at least in northern Greenland. In the south, however, it must have receded. Everywhere there are evidences of oscillation in the extent of the ice-flow. Koch notes several glaciers on the north-west that advanced until 1920 and are now retreating and one, the Brother John glacier, that is steadily advancing. Comparable oscillations are recorded from western Greenland.

In other parts of Arctic regions there is comparatively little development of glaciation to-day.<sup>1</sup> North-East Land, in the Spitsbergen archipelago, has a cap of island-ice rising in three domes to heights of over 2,000 feet with a gently undulating surface unbroken by nunataks. It leaves bare considerable areas in the north and west, and is evidently in a state of retreat. Giles Land or White Island, a little further east, is almost completely capped with *névé* or ice which is not a little remarkable, since the precipitation must be even less than on North-East Land. The ice-covering would appear to be a relic of the past. There is also an approximation to these conditions in New Friesland, but the greater part of Spitsbergen is covered by sheets of highland ice feeding valley glaciers that are either tidal or end in snouts or miniature ice-cliffs. In a few cases, areas of predominant wastage, piedmont glaciers, form along the coast. Evidently the Spitsbergen glaciers of to-day are only relics of an ice-covering that at one time may have submerged the whole archipelago. And

<sup>1</sup> Among the many terms which physiography owes to Prof. Griffith Taylor is the useful but discordant word "glacierized," meaning still covered with glacier ice, in contrast to "glaciated," which he would confine to meaning formerly, but not now, covered by glacier ice.

if the physiography of Spitsbergen has led to an opposite point of view it is only, as J. M. Wordie and G. W. Tyrrell have pointed out, because weathering by the action of frost, and the accumulation of talus have been so rapid that the traces of past glacier action have been largely obliterated.

Observation and measurement have proved several Spitsbergen glaciers to be retreating. Thus the Lillehöök glacier was retreating at a rate not less than 34 inches a day in July, 1909; a glacier in Bell Sound 4,900 feet in seventeen years; and one in Van Keulen Bay over 2 miles in twenty-six years. The Nordenskiöld glacier draining from New Friesland has lost about 2,000 feet in thirteen years.

On the other hand, a few glaciers have made striking advances, some no doubt of an intermittent nature, such as the glaciers in Wiche, Möhn, Agardh and Whales Bays and the Duckwitz or Gregory glacier on Barents Island. This suggests that precipitation increased over the gathering ground due to temporary variations in climate, or it may mean snow accumulates for several years before it overcomes the inertia of the glacier, and then causes a quick forward movement which rapidly clears away surplus and restores the glacier to its normal state.

Large areas in central Spitsbergen are almost entirely clear of ice to-day. This affords a puzzling problem which has not been satisfactorily solved. The solution can be found only in lack of precipitation in the interior which has caused the upland ice-sheets to shrink to such an extent that the valley glaciers have receded to mere hanging snouts or even less.

Novaya Zemlya was more heavily glaciated in the past than it is to-day when the ice-sheet is confined to the region north of lat.  $75^{\circ}$  N., with valley glaciers in the southern part of the north island and very little ice in the south island. O. T. Grönlie believes that during the height of the Pleistocene Ice Age, when the Barents Sea was covered by sea-ice or invaded by ice-sheets from Europe and Spitsbergen, precipitation was probably too scanty for heavy glaciation in Novaya Zemlya.

The islands of the Franz Josef Archipelago have nearly all extensive coverings of *névé* ice which shows a very slow outward movement, as if accumulation and waste were balanced,

They, too, were heavily glaciated in the past. Nicholas Land is heavily glaciated, but nothing is known of the state of the ice. Islands further east, including the New Siberian Islands and Wrangel Island, bear no glaciers.<sup>1</sup> They have limited gathering grounds and probably low precipitation, but the absence of glaciers is more likely to be due to the lack of glaciation in that area during Pleistocene times owing to distance from the open ocean. The coldest part of eastern Siberia to-day has a depth of only 10 inches of snow in February, which is the month of maximum snow-covering.

<sup>1</sup> Bennett and Henrietta islands have some valley glaciers which, to judge from the small bergs they shed, are made of *névé* snow rather than ice.

## CHAPTER XII

### POLAR VEGETATION

ONE of the most surprising features of Arctic scenery is the variety and relative wealth of plant life. To say that several hundred species of flowering plants and ferns and a great many mosses and lichens have been recorded from Arctic regions gives but a poor idea of the vegetation. Certainly it is localized. There are bare areas devoid of any close covering of vegetation, but seldom devoid of a few scattered plants. Except on glaciers, moving moraines and ice-caps, there is no complete desert ; even exposed mountain crags support some plant life. On the other hand, there are luxuriant oases quite inconsistent with the prevalent conception of Arctic barrenness. Every Arctic traveller remembers his surprise and delight when for the first time in high latitudes he came on meadows of rich grasses, bright with tall yellow buttercups, luxuriant saxifrages, violet cuckoo flowers, blue polemoniums, or many other flowers ; moorlands purple with saxifrage as a Scottish hillside is with heather ; peat bogs white with myriad tufts of waving cotton grass ; dry banks with their hundreds of sturdy white and yellow poppies, clumps of red and yellow saxifrage, dryas, champions and other blooms ; or some wind-swept summit on which the Arctic poppy triumphantly flowered. Even ferns and horse-tails occur in the Arctic. Latitude has little relation to the luxuriance of Arctic vegetation : in northern Greenland, where only July has a mean temperature above freezing-point and all precipitation falls as snow, there are some of the richest Arctic meadows and over 120 species of flowering plants. Elevation is more important, not only through exposure to cold winds, but also owing to a longer and perhaps continuous snow-covering.

In a general way Arctic vegetation may be likened to that

of the tundras of northern Canada and Siberia. It differs in containing fewer species and being discontinuous in its covering of the ground, but it is largely similar in the characteristics of plant forms exhibited. More precisely the chief formation shown by Arctic vegetation is that which E. Warming has designated *fjaeldmark*, sometimes translated as *fellfield*, or in German *felsenfluren* or *gesteinsfluren*. In one form or another *fjaeldmark* extends to the point where vegetation ceases on the glaciers and icefields: it is more or less open and discontinuous and marked by dwarf stature and slow vegetative growth of flowering plants and an abundance of cryptogams. Another formation of wide importance is a wet tundra in which mosses thrive better than flowering plants. Wherever *phanerogamic* vegetation is varied and luxuriant, the cause is certain to be found in the nitrogenous matter washed from adjacent bird rookeries. These are always near open water and not infrequently give coastal areas patches of rich vegetation, but when they occur in sheltered places well up the fjords, where mist interferes less with the action of light, they are most effective in encouraging plant growth.

Although vegetable humus is very deficient it is not a lack of nutritive substances in the soil, provided soil occurs, so much as climatic factors that curb plant growth. In more favourable sites in south-west Greenland and the Canadian Arctic Archipelago, continuous heath and wide stretches of grassland are not uncommon. The low altitude of the polar sun gives singular advantage to sloping ground provided that it is not too steep to give stability to the loosely coherent soil. Th. Wulff made observations in north Greenland which show that in favourable sloping sites with a dark background plants experience in calm sunny weather, not an unusual Arctic occurrence, a much higher temperature than the general air temperature of the district.

The permanent snowline in the Arctic is several hundred feet above sea-level. This frees all the lower ground for some months in summer and allows scope for vegetation. Nevertheless, the melting snow, both on the low ground and at higher altitudes, is hostile to plant growth in at least two ways. Torrents of water rush down from the heights in early summer, river courses flood, channels shift year by year, and thick

layers of glacial débris are spread over the plains. Great destruction of plant life results. Apart from this purely mechanical action, the deluge of water has a further influence on plant life. All the lower ground where plants can lodge is saturated with ice-cold water: the lower the gradient the longer it takes to drain. At the foot of moraine slopes marshes and bogs are very common, and on the raised beaches ponds are numerous, of which some are permanent and others dry up during August. In the wet tundra mosses are the predominant feature and flowering plants of little importance, though cotton grass is often conspicuous.

One or two feet below the surface the scanty soil is frozen even in the height of summer. On this solid subsoil the upper layers, when charged with water, are slowly creeping downhill only to be checked during winter frost. Wherever there is the slightest slope the soil is moving. Fine soil has little chance to lodge and accumulate, and even on the level it sinks with percolating water. Only the solid rock, that affords poor lodgment for plants, is stationary. That this lack of fine soil is prejudicial to plant life is easily seen when the luxuriance of growth is noted in places where soil can lodge. On a stony plain the ridges are often bare, but in the hollows where a little soil can collect there are patches of vegetation. In certain parts of Spitsbergen the "crests and troughs" of the raised beaches can easily be picked out in this way. And of course where once soil collects and plants grow the mat of roots and the added humus helps to hold the soil.

In temperate regions soil owes a great deal to earthworms mixing the layers and to the action of bacteria on vegetable matter. In Arctic soils earthworms are rare, and where they occur are small and apparently ineffective even if fairly numerous. Certain soils in Spitsbergen immediately above the ordinary tide-mark show an average of 1.75 to 2.3 worms per square centimetre: on drier raised beaches the average is only 0.16.

Putrefactive organisms have been found in several Arctic and Antarctic soils, but they cannot be abundant or active since organic matter, especially timber, decays very slowly. Logs that must be several centuries old occur in sound condition in many raised beaches. Several examinations of Ant-

arctic air have found it to be sterile except where contaminated by contact with soil or vegetation. Observations have been made in Spitsbergen and the Antarctic on bacterial flora in the intestinal tracts of animals. In the Antarctic bacteria have generally been found in small numbers, while from the Arctic a number of negative results can only be regarded as inconclusive.

Arctic plants have to contend with several unfavourable climatic factors. As a rule they do so successfully, since sturdy if small plants are common. The period available for active growth and reproduction is from two to four months. For the rest of the year the temperatures are below freezing-point and the ground is snow-clad or, if bare of snow, exposed to great cold. In consequence wind-swept places have a poor and very open vegetation; ground covered with winter snow affords better sites, especially if the snow collects early in autumn and melts early in spring, for snow is a poor conductor of heat and so protects the plants. Bare ground, however, provided it is stable, supports lichens in spite of the lowest temperatures. They are even found in places where no moss will grow. Low air temperatures in themselves are supportable by plants, thus the Siberian larch suffers no ill-effects in  $-60^{\circ}\text{F.}$ , but low air temperatures coinciding with low soil temperatures are injurious. Transpiration when the ground is frozen and no moisture can enter the root hairs is fatal. Even when the moisture is liquid its low temperature decreases its value: it is physiologically inactive. Trees with their large transpiring surfaces cannot grow except in very sheltered spots. For the same reason many plants are low-lying and even creeping and have reduced transpiratory surfaces. In Arctic regions with high wind velocity the northern limit of trees is depressed. It is nearest to the Pole in eastern Siberia where the winds are relatively light. In the Lena delta larches thrive as far north as lat.  $72^{\circ}\text{N.}$  On Bering Strait trees seldom grow north of lat.  $60^{\circ}\text{N.}$  In sheltered places in the Mackenzie delta, Alaska and south-western Greenland, a few trees grow but somewhat grudgingly. A 20-foot birch in Greenland merely shows that in the south-west of that country the climate is not truly Arctic. A willow 8 feet in height has been noted in Victoria Island, but this is an

exception. Creeping willows and dwarf birches with stems of an inch or two in diameter are the nearest approach to trees under true Arctic conditions.

Arctic plants have to hurry their life cycles in a short summer from June to August. Flower buds not infrequently open before the snow is off the ground. At the first suggestion of spring they are ready to burst into bloom. Development is almost explosive. But even then a great many plants seldom or never produce ripe seed. Vegetative reproduction by shoots, runners or bulblets is common. Insects, including flies, bees and butterflies, occur, but self-pollination often takes place. Flowers, as in alpine species, are bright coloured and profuse but scent is uncommon. Most plants are perennial: annuals are rare on account of the brevity of the growing season. Thus Spitsbergen has only 2 per cent. and Alaska only 1 per cent. of annuals in their floras. Cushion or tufted plants are common, a defensive adaptation to rigorous conditions. Roots and subterranean stems show abnormal development in the loose soil poor in nutriment. Mosses are common Arctic plants and their prevalence, it has been suggested, may possibly be due to their capacity for developing a high osmotic pressure. Lichens are common everywhere on bare rock and stony ground. Fungi, including puff balls, are found locally.

Scanty as Arctic vegetation is on the whole, there is nevertheless some plant life of economic interest and direct value to man. Meadows rich enough to support the musk-ox are of widespread occurrence in the Canadian Archipelago and in Greenland. There and elsewhere the caribou, reindeer and other herbivorous animals also thrive, living on the twigs and leaves of willow and other plants (Chapter XIII).

It is doubtful if such fastidious eaters as horses and oxen could find sufficient nutriment, though in some of the Spitsbergen mining camps horses enjoy the outdoor grazing for a few weeks in summer, and in certain of the southern valleys of Greenland the Danish residents used to keep a few cattle which thrive on natural pasture in summer: goats prospered better.<sup>1</sup>

<sup>1</sup> Of old Norse settlements the *King's Mirror* says that pasturage was good, that there were fine farms with many cattle and sheep, and that butter and cheese were made in great quantities.

The shortness and low temperatures of summer prevent any corn crop being grown even if the soil were rich enough. In a few places in southern Greenland cabbages, turnips, carrots and radishes have been raised: potatoes produce only tiny tubers, but rhubarb does moderately well. Away from the Danish settlements the Eskimo make no attempts at cultivation. Efforts to grow vegetables in Spitsbergen have failed.

The native vegetation, however, provides some food. Ripe berries of the crowberry or curlewberry (*Empetrum nigrum*) are widely spread. In places in southern Greenland they are so plentiful as almost to blacken the ground. The Danes make them into preserves. The Eskimo eat them, considering them a luxury when mixed with blubber. The blue-black blaeberry, bilberry, or bog whortleberry (*Vaccinium myrtillus*) is less common. In Greenland the Danes make use of them, but the Eskimo often think them unwholesome. The cowberry or false cranberry (*V. vitis-Idæa*) is rare and local, and seems to be at the limit of its distribution. It is seldom eaten or indeed ripe enough to eat. The cloudberry, or mountain raspberry, or salmon berry of Alaska (*Rubus chamaemorus*), rarely produces ripe fruits in Greenland or Spitsbergen. In Arctic Canada its fruits are eaten by the Eskimo, although in Coronation Gulf Stefansson found a tribe with a strong prejudice against them. Of other plants the scurvy "grass" (*Cochlearia officinalis*) and the sorrel (*Oxyria digyna*) are the most useful. As a preventive of scurvy the value of these plants was realized in very early days. Dutch winterers in Spitsbergen in 1633 collected "salad" for the preservation of their health: "we boiled a beverage of salad which our cook was to drink for the scurvy." At a later date Russian trappers in the same land were using these plants. According to Rink the Greenland Eskimo do not use them, but P. Freuchen says the Smith Sound Eskimo prize highly the sorrel. On the other hand, W. Werenskiöld maintains that sorrel is unhealthy and promotes jaundice. Other plants that Eskimo use are the *Pedicularis lanata* and *Silene acaulis* for kinds of soup; willow leaves eaten raw with boiled meat; the flowers of the purple saxifrage (*S. oppositifolia*); the young raw stalks of angelica (*Archangelica officinalis*); and various kinds of

seaweed. Among the Smith Sound and some other Eskimo the commonest vegetable food is the mass of slightly digested plant food found in the paunch of the musk-ox and caribou.

In Greenland a little fuel is provided by birch, willow, juniper, crowberry and other shrubs. A poor quality of peat occurs in many Arctic lands, and is used a little for fuel and building.

Iceland (*Cetraria*) and reindeer (*Cladonia*) "mosses" are found widely in Arctic lands. They are eaten by caribou and reindeer but are far from being their chief food.

There seems to be little doubt from the geological evidence that during the period of maximum glaciation in the Pleistocene ice-age all vegetation disappeared from Arctic lands. In the Asiatic and European Arctic islands, including Spitsbergen, ice at one time or another probably covered the land except for a few solitary nunataks. Greenland was also completely covered except perhaps the extreme north, but the Arctic Archipelago was probably fairly free from ice, while ice-sheets were found in Canada (p. 106). Whether by reason of ice-covering or of extremely low temperatures in summer plant life was exterminated and all Arctic floras are due to post-glacial migration from the south. Every Arctic flora has many circumpolar species, and indeed there does not seem to be a striking difference between the floras of widely separate lands. Thus Spitsbergen with 124<sup>1</sup> species of flowering plants has 117 which also occur in Greenland and America, and Greenland has 416 species of which 76 are circumpolar and the rest mainly American and European, while the Arctic coast of Canada has 230 species of which 84 are circumpolar and a great many are found in Arctic Europe and Asia. Novaya Zemlya has 189 species, all of which are found on the mainland to the south. Franz Josef Land has a flora of 23 species closely akin to those of Novaya Zemlya and Spitsbergen.

C. H. Ostenfeld believes that a small number of Greenland plants are survivors of a preglacial flora, but that most are post-glacial immigrants, principally from America, and that the European element came partly from Spitsbergen and partly from Iceland. A few may have been introduced by the early Norse settlers.

<sup>1</sup> This number has now been slightly increased.

The extreme likelihood of this relatively recent migration northward of Arctic plants is strengthened by the small number of endemic species. Time has not been long enough for new species to evolve. Thus Greenland has only one or two, Spitsbergen none, the Canadian Archipelago four and Franz Josef Land none. The chief agent in the dispersal of Arctic plants must be wind, the effectiveness of which is qualified by the occurrence of arms of the sea and wide glaciers which intervene between localities suitable for plant life. Even more does wind fail to disperse species because of the lack of ripe seeds. Ice seldom if ever helps to disperse plants, although a frozen fjord may give a surface over which seeds may be blown. Great importance used to be attached to migrating birds as agents of dispersal, but since birds generally migrate on an empty stomach their efficiency in spreading plants can be only in the case of those seeds that cling to their feathers. The ptarmigan, a true Arctic bird, is apparently an exception. It lives partly on the berries of Arctic plants (also willow leaves and saxifrage shoots and buds), and passing the seeds through its body no doubt spreads the crowberry, bilberry and other plants of that nature.

The contrast between Arctic and Antarctic is strikingly shown in the almost total absence of land vegetation in south polar regions. Only two rare flowering plants have been recorded (*Descampsia antarctica* and *Colobanthus crassifolius*), and these only from the northern and more open parts of Graham Land and the South Shetlands. Both species are poor, dwarfed and vegetative in reproduction in their Antarctic habitat and are more at home in Fuegia, the Falkland Islands and South Georgia. There are no ferns, but mosses are numerous in individuals if not in species which amount to about fifty up to the present. Many specimens show vigorous and even luxuriant growth, but those from the more southern coasts, for all plant life is coastal, are often stunted and puny. Mosses generally grow in small colonies in favoured places and may even, along with lichens, form a carpet of vegetation covering as much as half an acre or more. Such favoured spots are due to bird guano supplying nitrogenous matter. Fruiting specimens are rare and only some six species have been recorded as showing this form of reproduction. A

few hepatics and liverworts are found among the mosses in places. Lichens are numerous both in species and in individuals and form the chief aspects of Antarctic vegetation. Many cliffs even in midwinter show grey or orange with thick coverings of lichen, while in summer there is scarcely a rock to be seen without some lichen growth. About 100 species have been recorded and no doubt more will be found.

The poverty of Antarctic plant life is easy to understand, for the fundamental reason lies in the lack of any real summer as far as temperature is concerned. There is no month with a mean above freezing-point. As a result the snow lies late on the ground and December is well advanced before the sun's rays lay bare what little soil occurs in a few places. By early February the snow again begins to accumulate. Only for four to six weeks is the vegetation, excepting lichens on cliff faces, exposed to sunlight. The ground thaws to a depth of a few inches only on a few cloudless days about midsummer and even then is probably saturated with ice-cold water. There is practically no possibility of higher plants completing their life cycles in these conditions. The low winter means, as low as  $-30^{\circ}$  F., on some coasts are probably no more detrimental to plant life than means of zero. Antarctic mosses, which are frozen solid for ten or eleven months, grow vigorously for the rest of the year.

In addition to these principal causes there are contributory factors that militate against plant life in the Antarctic. The chief sites for plant growth are small islets and rocky coasts. In such places winds help to clear the snow, but they are cold dry winds in themselves most hostile to plant life.

Lack of soil is less important since many a spot with quite as much soil as Arctic vegetation thrives on is devoid of plants. But the penguins are certainly an important factor. In spring and summer they occupy practically every site which is at all favourable for plants and nothing escapes their insatiable curiosity or fails to be attractive to their beaks. No plant that had gained a footing on a penguin rookery would stand much chance of survival. This destructive influence does not occur in the Arctic.

A few samples of soil from Victoria Land proved to be alkaline due to the accumulation of salts, carbonates and

zeolites and the absence of organic acids. Chemical changes in the soil are evidently slow. It is of interest, however, to note that these soils are not valueless for plant growth. D. Mawson records an experiment in Adelaide of growing wheat in these samples. "The wheat germinated earlier than usual and showed unusual vigour and growth, demonstrating the suitability of the soil as a plant food."

An analysis of the scanty Antarctic flora shows three elements, endemic, Arctic and Fuegian. The high proportion of endemic species can well be explained by long isolation and peculiar conditions of environment. Two explanations of the Arctic element have been suggested. Carriage of spores and sores on the feet and plumage of birds like Wilson's petrel and the Arctic tern, which wander through 150° of latitude, might account for some species, but it is difficult to find in this suggestion an adequate explanation of the fact that half the Antarctic lichens and 30 per cent. of the mosses are found also in the Arctic. A more credible explanation is either that the species in question are cosmopolitan and have not yet been found in low latitudes, or that they are species that have been crowded out by stress of competition in low latitudes where happier conditions lead to more rivalry for location. The Fuegian element, one might say the Fuegian relationships of most species, shows that the present flora has reached the Antarctic continent and islands by the prevailing westerly winds from South America, birds no doubt playing a part. Ice transport does not occur outside the pages of a few textbooks. There is direct evidence in the form of pollen grains of a Chilean conifer, *Podocarpus*, found among red snow at the South Orkneys, that wind or bird transport is effective. Probably the flora reached Graham Land and adjoining islands and then spread eastward round the rim of the continent. Former land connections can have been of no avail since these disappeared before the last great extension of Antarctic glaciation, which must have effectively destroyed every vestige of vegetation in the far south. The present flora must have reached the Antarctic in recent geological times.

Physical conditions in polar seas show little difference between north and south. This similarity is reflected in the nature of the marine vegetation. Coast algæ are few, for the

scouring action of the sea-ice prevents much growth between tide marks. Of course, where glaciers reach the sea no littoral vegetation can exist. But strange to say algæ grow at times in pools which are frozen solid every winter. Luxuriant species like *Laminaria* and *Macrocystis* flourish on coasts that remain open and are little exposed to drifting pack. On true polar coasts, however, it is rare to find any but calcareous encrusted algæ in the shore pools: they can survive the erosive action of the ice. The low temperatures of the sea-water, much the same both north and south, do not in themselves prevent a rich growth of algæ. This is found on floors of most polar seas in shallow water. In 10 fathoms, for instance, some ten or eleven species were taken from a single bay in the South Orkneys. This algal flora continues as far as light penetrates. A deterrent influence in the Arctic is the low salinity due to the enormous amount of fresh water poured into the sea. This no doubt accounts for the poverty of the flora on the coasts of Siberia. In the Antarctic this influence is not noticeable.

Some of the earliest voyagers in Arctic seas commented on the variation in colour of the sea-water, but W. Scoresby was the first to attempt an explanation. He attributed the discoloration, varying from grass green to brown, to immense numbers of medusoids in the sea. For many years this explanation was accepted. The truth was first discovered by R. Brown who found the cause was the presence of vast quantities of diatoms. The discoloured patches which vary in size from a few yards to many acres are common in the Greenland Sea, Davis Strait and other parts of open Arctic seas, and somewhat less common in the Antarctic seas. The yellowish or brownish tinge on ice-floes is due to the same cause.

Polar seas hold prodigious quantities of diatoms: a silk townet is filled in a few minutes' haul with a gelatinous mass composed almost entirely of these unicellular microscopic plants each encased in its siliceous test. They are the chief feature of polar plankton: in warmer seas they are comparatively rare and never occur in numbers sufficient to form, after death, the deposits of diatom ooze which are so characteristic of the sea floor in high latitudes. Various reasons have been assigned for this prolific plant life in cold seas.

Diatoms are holophytic, that is to say they synthesize their food from free carbon dioxide in the water, nitrates, etc. Animal metabolism is continually setting free these substances in the deeper layers of the sea. These deeper layers in cold seas are continually rising to the surface as the surface water, cooled in contact with the cold air, sinks. It is owing to this vertical circulation that these substances essential for plant life are ceaselessly replenished in the photic zone, or those layers of sea which are penetrated by light and in which alone can green plants function.

Other causes also operate. In cold seas denitrifying bacteria are less abundant and certainly less active than in warm seas. The result is that in cold seas the nitrogen compounds on which the diatoms depend are destroyed very slowly. Moreover, if free oxygen is present these bacteria are said not to attack nitrates and in the polar seas this is likely to be the case. Another factor in favour of diatom growth is the greater abundance of silica in water of low than of high salinity. In polar seas the salinity is low in those intermittently open waters girdling the more persistent ice areas. Moreover, the great abundance of rock-swept waste in polar seas affords a large supply of silica.

Among the fresh-water algæ the most interesting are those that colour snow. Red snow is the commonest and is found both in Arctic and Antarctic, either in small or large patches. It is generally caused by a unicellular red alga (*Sphaerella*), which, however, is not confined to polar regions. Red rotifers have been found occasionally in the Antarctic and the Alps to cause a similar colouring of the snow. In other cases red snow may be due to the droppings of little auks.

Yellow snow on ice-floes is due to diatoms and is very common, but on glaciers it may be due to a fresh-water alga. Another alga rarely causes green snow. Fragments of desiccated lichens as well as fine rock dust occasionally colour snow black or brown.

Some scanty deposits of a peat-like material found in small fresh-water lakes in Victoria Land and Ross Island are composed of algæ. They have not undergone the partial decomposition characteristic of peat.

The vegetation of South Georgia, the Crozets, Heard, Ker-

guelen, Macquarie and other sub-Antarctic islands, is a form of poor tundra covering the lower ground more closely than in Arctic islands but much poorer in species. There are no trees, owing to the low temperatures and high winds, and mosses and peatbogs are numerous. Among higher plants tufted species flourish best, no doubt owing to their power to resist the cooling influence of winds (p. 116). On many islands tussock-grass grows high and luxuriant giving an impression of rich vegetation.

The flora of these islands must be wholly, or at least almost entirely, post-glacial, which accounts for the poverty of species. South Georgia has eighteen vascular plants, Kerguelen thirty, and Macquarie Island thirty-four. Many of these species are circumpolar in distribution, and most are of Fuegian origin; some in Macquarie Island are found in New Zealand but not in Fuegia. There can be little doubt that the post-glacial species of these islands were brought by birds and winds from the west and to Macquarie Island also from the north-east. The poor and uncertain means of transport, the inclement weather conditions, and the ravages of penguins account for the poverty of the flora.

The fossil trees of Kerguelen, sometimes dignified by the name of coal or lignite, must be relics of a pre-glacial flora. They are found in Tertiary basalt flows which no doubt were largely instrumental in destroying the forests before the ice-age set in. This deposit is so abundant in places that proposals have been made to mine it to supply a coaling station for passing vessels. Even if it were good steam coal instead of indifferent lignite with a high proportion of ash and low calorific value, the position of Kerguelen with relation to trade routes renders such a scheme unpractical.

Botanically the Falkland Islands may also be regarded as sub-Antarctic. They show the same lack of trees and the same prevalence of peat bogs. But it is outside the province of this book to treat of these islands, which are much more nearly related in all aspects of geography to South America than to the polar regions.

The presence of great quantities of timber on many Arctic shores is curious in these treeless lands. Its distribution is wide. Many shores of Spitsbergen are littered with it, and

some are piled high with tree trunks like untidy timber yards. It is plentiful on the coasts of Novaya Zemlya, Kolguev and Bear Island, Jan Mayen, somewhat scarce and local on the islands of the Canadian Archipelago, but abundant on the south-west coast of Greenland and the shores of the Mackenzie delta and eastward through Coronation Gulf and many parts of the Arctic coast of Siberia and the New Siberian Islands.

It is invaluable to the Eskimo as their only source of timber for weapons, sledges and boats, while to the trapper and explorer it provides fuel and often the means of building shelter.

The driftwood consists mainly of the stems of coniferous trees among which Siberian larch and spruce are common; most of it has not been long in the water but some water-logged pieces are found. The source of most of this wood is the Siberian forests. When great rivers, as the Yenisei, Lena, Kolima and many others, come down in spring flood they overflow their banks, uprooting trees in their course. These trees are swept into the ocean and carried across the polar basin in the great surface drift, eventually to be thrown up on various Arctic coasts (see pp. 74, 75). The Mackenzie contributes its share to the Arctic coast of Canada and the Coppermine adds a little. But the Great Slave and Great Bear Lakes trap much that would otherwise reach the ocean. The discovery of beans of West Indian origin in Greenland, Spitsbergen and Novaya Zemlya, and birch bark from Indian canoes on the coast of Greenland, shows that the North Atlantic drift, deriving material partly from the Gulf Stream, contributes a little to the jetsam on Arctic coasts. After the war several mines and some wreckage from torpedoed ships found their way to Spitsbergen by the same route, while copper floats of submarine nets and glass floats of Norwegian fishing nets (found also on Spitsbergen) reach Jan Mayen by back eddies of the Spitsbergen current, or by encircling the Greenland Sea and eventually drifting south with the East Greenland current.

## CHAPTER XIII

### ARCTIC ANIMAL LIFE

IN spite of the relatively poor vegetation and climatic conditions that might appear adverse Arctic animals are numerous both in kinds and numbers. Except the ice-caps, no Arctic land is devoid of fauna and few even give an impression of lifelessness. Most noticeable of the land animals is the herbivorous musk-ox or ovibos (*Ovibos moschatus*) which are sometimes called polar-cattle. (It feeds on grass and willow leaves, but rarely on moss and lichen, and used to have a wide range in the American Arctic. Now it is found mainly in the Barren grounds, the western islands of the Arctic Archipelago, in Ellesmere Island and north-west and east Greenland. In the far north and on the west and south-west of Greenland it does not occur and it is absent from the Arctic islands of Europe and Asia.) At one time it had a wider extension and was more numerous, for it is much hunted and, being slow moving, is an easy prey to hunters armed with even primitive weapons. M'Clure reported musk-ox as numerous in Banks Island in 1850-53, but the iron looted by the Eskimo from his abandoned *Investigator* has helped to exterminate them. They do not move south in the winter and never go out on the sea-ice: Stefansson says that a musk-ox never leaves the island on which it was born. Its only enemy besides man is the wolf, which it fights with its sharp horns. A lone beast is occasionally killed but the musk-ox seek safety in numbers and the herds in which they move are seldom attacked.

Stefansson believes that the musk-ox could be domesticated and bred for both meat and wool. The meat is palatable and free from odour and the fleece gives about 10 to 15 lb. of wool a year. But shearing might leave the animals a prey to weather and the attacks of mosquitoes.

The caribou or reindeer (*Rangifer*) is more widely spread

and some kinds range far south of the true Arctic regions. There are nine species or sub-species in Greenland and Arctic America and others in Europe and Asia. (In fact the reindeer seems to be so variable an animal that slight differences in environment result in distinct varieties.) Even Spitsbergen has its own species according to some zoologists. On the whole northern forms seem to be smaller than those living on richer vegetation further south but the contrast is not without exceptions. All forms interbreed freely. The name caribou used to be in favour in America and reindeer in Europe, but now there is a tendency to use reindeer for domesticated caribou both in Canada and Alaska. All Arctic lands except Franz Josef Land and a few small islands support reindeer. The New Siberian Islands were actually discovered by hunters following the trail of great herds of reindeer passing north over the sea-ice. In Franz Josef Land the dearth of pasturage may account for its absence, but recent bones of reindeer suggest that possibly the Spitsbergen reindeer travelled that way from Novaya Zemlya, crossing the pack between the island groups. There is evidence, in Spitsbergen deer with Samoyede markings on their ears, that these movements do occasionally occur. A. E. Nordenskiöld's suggestion that the Spitsbergen deer come from an unknown land to the north-east did not solve the problem and in any case is untenable; but the recent discovery of Nicholas Land with an unknown northerly extension may possibly indicate a route from the Siberian tundra.

The chief food of reindeer is shoots and leaves of willow, *Empetrum vaccinium*, birch, etc., in summer, and lichens such as reindeer and Iceland "mosses" in winter. They even feed occasionally on sea-weed. Where possible they migrate south in winter but are quite capable, as in Spitsbergen and Greenland, of finding food in the far north all the year round. With the broad hoof they can dig away from the herbage they seek as much as 4 feet of snow. Modern firearms in the hands of the Eskimo have greatly reduced the number of reindeer which are hunted for skins, meat, bones and sinews. In Spitsbergen the work of Norwegian hunters and trappers and of "sportsmen," of many nations, has almost exterminated them. The annual reindeer hunt used to occupy most of the Greenlanders for two or three months in the year. Between 1845 and 1849 as many as

25,000 head were shot annually. After the demands of the population were met there were many slain for export. That source of wealth and wellbeing is now exhausted except among the Polar Eskimo. The Spitsbergen hunters used to take some 3,000 head a year eighty years ago: latterly a few dozen was a good bag. Fortunately for its hope of survival the reindeer is now protected by Norway: none may be shot in Svalbard until 1934. The country by that time should be restocked with sufficient reindeer to provide a valuable source of food for the growing mining population, if the hunting is carefully controlled (see p. 174). The reindeer is domesticated in Siberia and Lapland and has been introduced for the same purpose into Newfoundland and Alaska, but the Eskimo have never tried to tame the caribou. The possibilities of the reindeer industry are discussed in Chapter XXI.

Some smaller herbivores are of less importance except in some cases for furs. The white Arctic hare (*Lepus glacialis*) is widespread in the Canadian Arctic and Greenland. It feeds largely on willow leaves. Occasionally where the vegetation is rich they are found in flocks. They do not migrate in winter and have always an enemy in the wolf. The lemming (*Myodes torquatus*) is a small timid creature which hibernates in winter. Where vegetation is rich it abounds. Its foes are gulls and hawks. The same species is found throughout the Arctic, but it is absent from Spitsbergen.

Beasts of prey are of several species. The ermine (*Mustela erminea*) is infrequent in the Canadian Arctic, and east and north-east Greenland. It really belongs to the southern borders of the Arctic where it is hunted for its fur. The glutton (*Gulo luscus*) reaches the Arctic only in the Canadian Archipelago where it preys on reindeer but it is rarely seen. No doubt Fabricius in his *Fauna Greenlandica* (1780) referred to this beast in the animal known as Kappik. The skin finds a ready market.

A carnivore of greater frequency is the Arctic wolf (*Canis lupus*). It is generally seen singly or in small numbers owing, no doubt, to lack of prey. The Canadian Archipelago and northern and eastern Greenland seem to be the limits of its true Arctic range except the New Siberian Islands which it visits in the trail of reindeer. The well-known Greenland dog

is similar in appearance to the wolf from which it may be descended with certain crossings with European breeds from time to time. The Amarok, a fabulous wild creature of the West Greenland Eskimo, was probably the wolf; less probably it was a glutton. Vague reports of the wolf in Spitsbergen have never been confirmed by the capture of a specimen. The wolf lives on hares, foxes, lemmings and even seals with occasional reindeer and musk-ox.

In times gone by the Arctic fox (*Canis lagopus*) was the commonest of land mammals in the far north. There are two varieties, the blue fox with a bluish grey coat, and the so-called Arctic fox, pure white in winter and brown and white in summer. The fox is found throughout the Arctic, including Spitsbergen, Jan Mayen and Franz Josef Land. This wide migration is explained by the fox being more a sea than a land animal. In summer it feeds well at bird rookeries and on lemmings and ptarmigan, where obtainable, but in winter lives largely on seal excrement and scraps of seal meat left by bears after a kill, taking care, however, to avoid close approach to a bear. Foxes have been seen hundreds of miles from land on the pack-ice of the Greenland Sea. It is thus that the Arctic fox avoids the necessity of making winter caches of food, or more probably it was driven to these tactics by lack of resources on land. The fox has been ruthlessly hunted for its winter coat. Fifty years ago Greenland exported 2,000 blue and 1,000 white fox skins, and in earlier years even more. Now the numbers are steadily dwindling. In Spitsbergen the destruction has been so complete that where twenty years ago foxes swarmed in hundreds not one is now to be seen and the bark is seldom heard. It is now protected by law, and if the protective measures can be enforced it is not too late for the species to recover its hold.

The white polar or ice bear (*Ursus maritimus*), which is the most characteristically polar of all Arctic animals, though an air-breather is really a sea-mammal, and is seldom found far from sea-ice. He is nomadic in his habits and lives practically throughout Arctic regions. He has occasionally been seen in the north of Norway and the north of Japan, for he is a powerful swimmer, and sometimes comes ashore in Newfoundland from the drifting ice. He is found in the inmost parts of the Arctic

Ocean, but is commoner near the edges of the pack where seals, and especially young seals, his favourite food, are more numerous. He also hunts the white whale, lemmings, birds and even salmon in some Arctic rivers, but apparently he leaves the walrus alone, though the Greenland Eskimo tell tales of battles between the two. Sometimes he eats algæ and grass, mountain sorrel and crowberries. He is almost omnivorous and will even manage to rifle carefully constructed depots of food and open tins of meat.

The bear is a large animal, up to 900 lb. in weight, of great strength and agility, using its forepaws as its chief weapon. He also uses cunning in securing his prey, in spite of his weight moving noiselessly over the floes. Although bears occasionally attack men they are usually timid and sometimes are easily frightened away without firearms. In regions where he is much hunted he always avoids man, though a hungry bear may prove troublesome and a mother will fight to protect her cubs. The bear is a solitary animal, as he needs must be in order to secure his tally of seals. It is only in early spring that male and female are seen together, but the cubs stay with the mother for a year or more. They do not hibernate but are on the move all the winter. Holes in snowdrifts excavated by bears are only for protection during bad weather or to shelter the mother while she is bearing her young.

The polar bear has been hunted ruthlessly by Eskimo and white men and its numbers are much diminished. In Spitsbergen and western Greenland it is becoming quite rare. Several hundred skins reach Arctic Norway annually from various regions. The old whalers always used to bring home a number of bearskins as trophies of the voyage.

Sea mammals are even more numerous for the Arctic seas teem with food. The real Arctic seals, except the walrus, all belong to the group of earless seals: the northern fur seal of the Bering Sea does not belong to the Arctic properly speaking. Of these seals there are many species of which the bladdernose or "klapmydsen," hooded seal (*Crystophora cristata*), and the Greenland, harp or saddleback (*Phoca greenlandica*), are the most important. Others are the sea-dog or selkie of the British coasts, the floe rat, "snadd" or ringed seal (*Phoca hispida*), the bearded or square flipper "storkobbea" (*Erigna-*

*thus barbatus*). The walrus, of course, is also a seal. The distribution of Arctic seals depends generally on the nature and extent of the pack-ice. They prefer regions of broken ice and open water and avoid areas of heavy congested pack where it is difficult to make breathing holes and if made to keep them open. There are seal deserts in the polar ocean where the currents are too sluggish to break the ice. Seals avoid these places in danger of suffocation. The relations between the distribution of seals and Eskimo are mentioned elsewhere (p. 149). Seals feed on fish, especially cod and herring, and various crustaceans, and are preyed upon by bears, sharks, killer whales or grampuses, and, most of all, man.

The harp or saddleback is widely spread in Arctic seas except in the seas north of Siberia and Bering Strait, and as it seldom makes breathing holes it lives in open pack near the edge of the ice. It even goes beyond the ice to northern Norway and southern Greenland, and has been seen on British coasts. Its chief breeding areas would appear to be three to which it makes long migrations annually in late winter or early spring. Nansen distinguishes three tribes, more or less clearly demarcated in their territory, each with its own breeding ground. He believes that the prevalence of small pelagic crustaceans in certain areas of the sea decides the location of the breeding places: these crustaceans being the chief food of the young seals.

The western tribe from Baffin's Bay, Davis Strait and Hudson Bay migrates southward along the coasts of Labrador with the strong current before the pack is moving. By March the young are born on the ice off Newfoundland, in the straits of Belle Isle and the St. Lawrence estuary. In St. Lawrence Bay many thousands are caught on the ice, but the great hunt is on the north-east of Newfoundland, where more than one ship took over 20,000 in a single trip last century and one as many as 42,000. In many years half a million seals were taken by the fleet of sealers, several making two trips, between March 1 or 10, the latter day the earliest date for steamers, and the beginning of April when the herds begin to disperse. The total catch by 10 vessels in 1925 was 128,000 seals. On the coast of Greenland the Eskimo hunt them chiefly in October and November, and in May, but then they are in poor condition.

The Greenland catch last century used to run to 30,000 a year, but now has fallen off. To the Eskimo this is probably the most valuable of all seals for its flesh, oil and hide. The hide is tougher and more suited than any other for kayaks. The Newfoundland hunt is both for skins and fine oil.

The eastern tribe of saddlebacks lives in the Kara and Barents Seas and breeds in the entrance to the White Sea where food and ice are both abundant. There some 20,000 are caught annually in March. Later in the year the survivors spread east and west along the coasts of northern Europe. The middle tribe stays in the Greenland Sea between Spitsbergen, Jan Mayen and Greenland where in March they congregate for pupping on the Great Ice Promontory, south of the Great Ice Bight on the edge of the pack. This breeding ground varies a little in position and ease of access from year to year. By international agreement sealing does not begin there till early April and is now pursued mainly by Norwegian sloops, but of old the Scottish whalers, as well as Dutch and German ships paid a spring visit to the Greenland seal fisheries, or "old sealing" before fitting out for the Davis Strait whaling. The total catch used to average some 200,000 saddlebacks. In 1916 the north of Norway sent out 173 sealing sloops which took between them 48,000 saddlebacks, as well as other seals. The hunting was then more intense than in recent years since seal meat found a market during wartime.

Next in importance, as in size, comes the bladdernose or hooded seal, so called from the loose skin on the snout of the male which can be inflated into a kind of hood. It is less common than the saddleback and has a more restricted range. Open drift-ice in Davis Strait and the Greenland Sea is its favourite habitat. It avoids close pack, rarely finds its way to temperate shores and seldom visits Eurasian Arctic Seas. There seem to be no definite breeding places of this seal. They do not congregate in large herds as a rule, but give birth to their young along the edge of the ice in the Greenland Sea and in Denmark Strait, avoiding the saddleback localities. After breeding they migrate, many going into Davis Strait. The Eskimo, who used to regard this as a difficult seal to hunt with lances, chase them chiefly in early summer. Last century the yearly catch in Danish Greenland was 2,000 to 3,000. Hunting

on a larger scale by Norwegian vessels used to be followed off the coast of East Greenland and around Jan Mayen. A vessel occasionally took 2,000, but more usually a few hundreds was considered a good catch. In Denmark Strait Norwegian and British vessels together used to take some 40,000 a year half a century ago, but numbers rapidly fell off. In 1902 only 19,000 were taken and now the hunting is almost at an end except for a few small Norwegian sloops. This change, however, is not entirely due to over-hunting, but largely to a loss of markets for oil and a fall in its price.

The walrus, sea-horse or morse (*Odobæenus rosmarus*) was one of the earliest Arctic animals to be known in Europe. It is mentioned in the account of Ottar's journey and in the *King's Mirror*. Apart from its great size it is conspicuous for its two great ivory tusks in the upper jaw, as much as 2 feet in length. These are useful to it in digging among the mud of the sea floor for shell-fish, clams, mussels, etc., which are its favourite food. Unlike the other seals it does not feed on fish. In the water it is active, but on land its movements are slow. A love of gregariousness has proved a fatal habit. Herds of hundreds and even thousands haul up on beaches together and make the hunter's task all too easy. It is an animal of the coasts and not of the high seas. Certain "walrus banks" far from land are shallow areas frequented for the food the sea bottom affords. The walrus is found throughout the Arctic including the Bering Sea, but its numbers have been so diminished by excessive hunting that it has virtually disappeared from some of its old haunts. When its numbers were greater occasional stragglers used to reach the coasts of Norway and north-western Scotland.

On Spitsbergen and Bear Island beaches it used to occur in thousands and was responsible for the first visits of hunters to those islands over 200 years ago: there is a record of 1,000 being killed in a few hours. Fifty years ago there were still many, but now it is rare even in the remoter parts. American ships used to bring enormous catches from the Bering Sea and north-east coast of Siberia, and walrus ivory used to be the chief export from Danish Greenland. The old Norse colonies in the fourteenth century sent their contributions to the cost of the Crusades in walrus tusks. Now the walrus is rarely seen

in Greenland except in the extreme north ; in Novaya Zemlya it is rare and in the Canadian islands far from abundant. In 1916 the polar hunters of northern Norway took only 136 between 173 vessels. Probably it persists in greater numbers on relatively inaccessible and little visited islands such as Franz Josef Land, the New Siberian Islands and perhaps Nicholas Land. The walrus is valued chiefly for its ivory, but the tough hides find a ready market. Its flesh, like that of all seals, makes good eating.

Whales and whaling are mentioned in another chapter, but several smaller cetaceans must be also noted. The white whale or hvidfisk (*Delphinapterus leucas*) has a wide Arctic range and is found in schools near the coasts. Its habit of following the ins and outs of the coast even round long inlets makes it a relatively easy prey to hunters who on seeing it entering a bay can spread their nets on the farther side and catch it as it emerges. The Eskimo of Greenland catch them for oil and meat while in Spitsbergen and Novaya Zemlya, Norwegians and, at Vaigach and off the Yenisei mouth, Russians and Samoyedes, used to pursue the fishing. A couple of thousand have been caught in one season in Spitsbergen, but now the pursuit has died out for want of whales.

Another small cetacean is the narwhal or unicorn (*Monodon monoceras*) which from early days has attracted attention and been hunted for its remarkable ivory tusk. It has nearly as wide a range as the white whale, but does not now appear on the coasts of Siberia, though Hedenström recorded it off the Yana mouth. It is no longer found in Spitsbergen waters, but has been recorded from Franz Josef Land. Everywhere it is becoming scarce and must be near extinction, which has been hastened by its gregarious habits that make it an easy prey to the hunter.

The Eskimo have a term "savssat" for the crowding of narwhal or white whales in a small space by the rapid growth of ice to seaward. Many hundred animals may thus be killed by the hunters because there is no escape. Not the ivory tusk alone is of value. The skin is stewed to make a jelly, the oil is useful and the flesh is eaten. In olden times the horn of the unicorn was valued as a medicine and still has some repute in China.

The grampus or killer (*Orcinus orca*), which has no commercial value, occurs wherever whales and seals are found and attacks them savagely. It is the one real beast of prey of northern and southern polar seas, and often drives seals and small whales inshore in terror.

In addition to these mammals there is a rich bird life in the Arctic. To enumerate all or even the majority of birds is beyond the scope of this volume. Land birds are not numerous. Few species winter in the north. Most widespread and loyal to its Arctic habitat is the ptarmigan, which varies its plumage so effectively with the season that neither in summer on stony banks nor in winter on snow is it easy to find. The snowy owl also winters, but is common only where the lemming, on which it preys, lives in numbers. The other birds are migrants coming north to breed in spring. The only song bird is the common snow bunting, one of the earliest arrivals. It is soon followed by such birds as the purple sandpiper, knot, turnstone, sanderling, grey phalarope, little stint, Lapland bunting, raven, redpole and Bewick swan, and several others, some circum-polar, some American and European in distribution.

Sea-birds are more numerous and nearly every Arctic land that has open sea near it in summer has its bird cliffs alive with myriads of nesting birds. Over the open pack-ice far from land, birds are not often seen, for feeding naturally is scanty. On the edge of the drifting ice is the fulmar; further north come the little auks, looms, black guillemots, puffins, various gulls including the ivory gull, kittewakes, skuas, geese and ducks including the important eider duck. The Arctic tern has the widest range of all, for it has been seen in lat. 74° S. and lat. 80° N.

Of all these birds the eider duck alone enters into the hunter's province. Vast quantities of eggs and masses of eider down are collected in Spitsbergen and Greenland, while the Eskimo value eider skins for light and warm clothing. Numbers are now much diminished. Rink estimated that fifty years ago 20,000 eider ducks were killed and 300,000 eggs were taken annually in Danish Greenland. The annual export of down was over a ton and a half: the present export is small. The eider duck is now protected in Spitsbergen.

Fish have always been of importance to the Eskimo, par-

ticularly cod, halibut and capelan in the sea and salmon in the rivers and lakes. Shark fishing has long been a pursuit of the Greenlanders. The Greenland or Arctic shark varies from 6 to 18 feet in length and is voracious but indolent and does not attack man. It collects in swarms around a dead carcass of seal or whale, and gorges till it can hardly swim. Its value lies in the liver, from which oil is extracted. In Greenland waters ten to twenty thousand used to be taken in a year and there was also a thriving Norwegian fishery in Spitsbergen which is now abandoned.

In recent years attempts at food fisheries for export to Europe have been made in the Arctic. Norwegian vessels fish cod and halibut on certain banks in Davis Strait, and herring as well as cod have been taken off Spitsbergen where the Norwegian State is exploring the possibilities of large scale fisheries. A kind of salmon, a red char, found in the rivers and lakes of Novaya Zemlya, Spitsbergen, Greenland and the Canadian Arctic Islands is used locally but does not occur in numbers large enough for export.

Of lower forms of animal life little need be said. There is no lack either on land or in the sea, but few come into direct relationship with man except certain insects of which the mosquito is the most significant. On the Arctic tundras the mosquito in aggressive swarms is the great curse of summer to man and beast alike: on the Canadian and Alaskan tundras he behaves no better and rivals sandflies and other pests in making existence miserable to man and reindeer. On western Greenland they are a curse in places, but in Spitsbergen they are rare and seldom annoy one. Happily the Arctic form of mosquito seems to carry with it no disease: the bites are painful but no ill results ensue.

Butterflies, bumble bees, spiders, crane-flies and gnats occur here and there and are mentioned merely to help to dispel the old misconception of an eternally frigid and cheerless North. An observation on insect life made in North-East Land by the Oxford Expedition in 1924 has an important bearing on the means by which insect and plant life can be borne across wide stretches of Arctic Sea. During the passage of a deep barometric depression from the south-west three sledging parties in different places on the ice-cap found large

numbers of living hover flies and aphids crawling on the surface. These have been shown by C. S. Elton to belong to the forest belt of Northern Europe, a distance of 800 miles. This occurrence shows how far and in what numbers insects, and of course small seeds, can be carried alive.

One extinct Arctic animal is still of great importance—that is the mammoth, a form of elephant with shaggy coat and long incurved tusks. It inhabited a wide range of country in Siberia, Europe and northern North America contemporaneously with prehistoric man, but has long been extinct and is known only, apart from ancient cave drawings, by the discovery of the tusks or whole beasts preserved in the frozen soil of the river valleys of northern Siberia from which they have been disinterred by the banks breaking away during floods. The New Siberian Islands, for some unexplained reason, contain the richest deposits of this fossil ivory. In order to collect it Yakut and other hunters cross from the mainland every summer, the only visitors to these little known islands. Many of the tusks are much weathered and in very bad condition, but all are collected. The best find their way into China and Russia for ivory work, but some remain with the Yakuts and Chukchees for combs, pipes, buckles and bowls. In 1913 about 20 tons of this ivory were reported to have come from the New Siberian Islands.

## CHAPTER XIV

### ANTARCTIC ANIMAL LIFE

**I**N comparison with the Arctic, the Antarctic shows few species of larger animals. There is no land fauna—no bear, fox, nor reindeer—not a single species has its home on the Antarctic continent. Herbivorous creatures could find no food, so carnivorous ones could get no prey. The only mammals are in the sea. Four kinds of seal are truly Antarctic: two others touch the fringe. Like the Arctic seals the four southern species are all earless seals. Commercially they fall into the category of hair seals since their hides are of value only for leather. They are all circumpolar in range, but vary much in their numbers. The Weddell Seal (*Leptonychotes weddelli*) is the commonest and is found on or near all Antarctic shores. It is so seldom found in the open pack that its presence in large numbers is a sure indication of the proximity of land. It breeds in spring in vast rookeries on fast ice near the land. Occasionally in winter it wanders to the Falklands, Kerguelen and New Zealand. In size it reaches over 9 feet and in weight 900 lb. It is lethargic in its habits and like most Antarctic animals entirely fearless of man, the outcome of ignorance rather than courage. A hundred years ago J. Weddell brought home the first skin of this seal which was grotesquely stuffed with a reptilian appearance and shown for many years in the Royal Scottish Museum in Edinburgh. It was regarded as one of the rarest of mammals until the Antarctic expeditions of this century proved it to be one of the commonest.

The white crabeater (*Lobodon carcinophagus*) while less common is not rare. It is not noticeably gregarious and is often found in the pack far from land. It is somewhat smaller and slimmer, more active and less gross and lethargic than the Weddell. It seldom comes ashore and seems to prefer

a proximity to open water, but rarely wanders beyond the Antarctic.

The Ross Seal (*Ommatophoca Rossi*) is the rarest of all Antarctic seals, and one of the least known of mammals. It has never been found in herds and its breeding places are unknown. Active in its habits and a powerful swimmer, it keeps to the floating ice but never wanders northwards. It rarely attains the size of the Weddell. No expedition has secured or even seen more than a few specimens of this mysterious lonely seal and some have not even got a glimpse of it.

The sea-leopard (*Hydrurga leptonyx*), so named on account of its ferocity, is the largest of all Antarctic seals. It may reach 14 feet in length and weigh nearly half a ton. It is not common and is never seen in herds. Not infrequently it visits Kerguelen, the Falklands and Macquarie Island. Nothing is known of its breeding places. The sea-leopard is alert and energetic in its movements, and feeds chiefly on penguins, the only seal that does so, which it chases in the water or seizes from the flocs. Alone among seals does the leopard threaten man, even without provocation.

None of these seals are hunted and so there is no likelihood of numbers diminishing. Here and there a few Weddells are killed, chiefly at South Georgia, but their value is small and they share the protection that is now afforded to all seals in the Falkland Island Dependencies. In 1893, the *Balaena*, a Dundee whaler, brought home 5,000 Weddell pelts but they did not find an attractive market.

Two sub-Antarctic seals have been ruthlessly hunted, the southern fur seal (*Arctocephalus australis*) and the sea-elephant (*Mirounga leonina*). The one is of value for its skin: the other only for its oil. A century ago the fur seal swarmed in the South Shetlands and was known also at the South Orkneys and South Georgia. Sealers nearly exterminated it at South Georgia and the Falklands early last century. Captain E. Fanning, with one of eighteen vessels, took 57,000 skins at South Georgia in 1800. By 1812 it was becoming scarce on the Falklands, and small wonder since a few years earlier one season's work meant 112,000 skins. In the twenties of last century many British and American vessels took cargoes

ranging from 5,000 to 20,000 fur seals at the South Shetlands and virtually exterminated the species in two or three years. J. Weddell recorded that 300,000 were taken at the South Shetlands in 1820-1. Very few have since been seen there. In 1885 two were taken and in 1915 one was killed at South Georgia. There were still a few at Kerguelen fifty years ago, but they are no longer hunted there. The last small cargoes of sealskins from those seas were collected by Canadian vessels about twenty years ago at the South Sandwich, and in pelagic sealing in Cape Horn waters. On Macquarie Island it was nearly cleared out a few years after its discovery in 1810. One ship took 35,000 skins and yet the industry continued for some thirty years. Rarely one or two are now seen.

The huge ungainly sea-elephant has a wide distribution on sub-Antarctic islands like South Georgia, the Crozets, Kerguelen, Heard and Macquarie. They visit the Falklands, Tristan da Cunha, Gough Island, the Campbells, and Aucklands, and are rarely seen among the ice at the South Orkneys, off Graham Land and even as far south as McMurdo Sound. The male reaches a length of 16 to 20 feet, twice the length of the female, and is also characterized by a curious dilated portion of the skin on top of the snout, hence its name. They are gregarious and spend much of their time ashore which makes them an easy prey to the hunter who has tracked them to all their island haunts. In South Georgia from 1910 to 1918 a total of 26,000 were killed, but the protective measures taken in 1919 appear since to have the effect of increasing their numbers. On Macquarie Island they are still numerous and on Kerguelen, where 2,300 were taken in a recent year, they are plentiful and are now nominally protected by France.

Of the whales without commercial value the killer or grampus (*Orcinus orca*), as in the Arctic Seas, is the beast of prey of the south. It attacks seals and even whales. Mr. A. J. Villiers in the Ross Sea lately witnessed a fight between five killers and a huge blue whale. Three attached themselves to the jaw, one on either side, and the third to the point, and two hurled themselves in furious rushes on his back as if trying to beat him to death. The whale fought valiantly but vainly with fins and tail to shake them off. He gradually succumbed and lay still and then the killers tore out his tongue and having

eaten it went their way. The white whale and narwhal are not found in the south. For the larger whales see Chapter XVI.

All birds are sea birds and summer visitors. Food in the sea is abundant and in numbers the birds make up for their lack of species and give life and animation to many Antarctic coasts for several months in the year. Penguins are the most striking and most numerous. The penguin is a sea bird of wide range in the southern hemisphere and is not confined to polar seas. The cooler parts of the southern continents and most oceanic islands have their penguin rookeries. Several of these southern species enter the fringe of the Antarctic Seas which on the other hand have also species of their own.

The most remarkable is the Emperor penguin (*Aptenodytes forsteri*) which is also the rarest and the most southern. A full-grown specimen stands 3 feet in height and weighs over 80 lb. It is slow and stately in its movements and not easily frightened but, like other penguins, can scurry quickly in a prone position over the snow, and swims with great speed. Generally the Emperors are seen solitary or in pairs except near their rookeries. They lack the love of noisy companionship which the smaller penguins seem to enjoy. The Emperor is a rare bird and only two or three of its rookeries are known where this strange bird lays its single egg in mid-winter on the surface of the snow. It places the egg on its feet and keeps it warm by covering it with a flap of skin and feathers. No wonder the mortality among the chicks is high and the bird is rare.

The other three Antarctic penguins are much smaller, more numerous and very plebeian in their habits. The commonest, most entertaining and certainly most human is the active black-throated or Adelie penguin (*Pygoscelis adeliæ*). It is about 18 inches in height. Its numbers are prodigious. Many an Antarctic coast in summer is alive for miles with the nesting birds, and discordant with their ceaseless chatter. A low estimate put the numbers on Laurie Island, one of the South Orkneys, with an area of only 30 square miles, of which 90 per cent is ice, at 5,000,000. These Adelies are the "population" of the Antarctic giving life and interest to its cold, silent scenes. Almost human in their behaviour with their

funny antics, strange conceits and little foibles the penguins are always welcome to the explorer, and are a sure sign that the long lifeless winter is over.

The Gentoo (*Pygoscelis papua*), more timid and less amusing, is found beyond the Antarctic, though essentially a polar bird, but the ringed penguin (*P. antarctica*), almost as active but less numerous than the Adelie, is confined to the icy seas.

Islands of the Southern Ocean have their own species, many of which do not migrate, including the large King penguin of South Georgia, Kerguelen and Macquarie Islands, which never enters the ice, the Jackass of the Falklands, and the crested macaroni penguin of South Georgia, Kerguelen and Heard Island which rarely strays to the South Orkneys.

It is not only abundance of food that accounts for the myriads of penguins. They increase because they have few enemies. Only the sea-leopard, and probably the killer whale, attack the adult penguin which means that on the land and ice they are safe. But skua gulls levy a toll of eggs and young on the rookeries.

Man has wrought some havoc among the penguins of southern islands, but he has left unmolested those of the true Antarctic regions, except in so far as explorers use them eagerly for the palatable food they offer.

At the Falklands there used of old to be an industry in boiling down rock-hopper and jackass penguins for oil. In 1868 one ship took 50,700 gallons of penguin oil and since each bird yields a pint this cargo signified the slaughter of 405,600 birds. For many years this industry has been abandoned, and penguins are now protected by law in the Falkland Islands and its dependencies. There is no evidence of a decrease in their numbers. Hunters at Macquarie Island (1913) took 130,000 penguins yearly, but yet there seems to be an annual increase in numbers. France has taken protective measures in Kerguelen, and a few years ago D. Mawson proposed that New Zealand should make Macquarie Island a national faunal reserve.

Many birds of the Southern Ocean visit the Antarctic in summer, and several nest on the islands and rocky edges of the continent. Petrels are most numerous, including the giant

petrel, or stinker of sailors, a gaunt carrion bird that varies in colour from white to grey or brown, the silver, Antarctic and snowy petrels, the last a fairly safe indication of land ; Wilson's petrel, a far wandering bird ; the Cape "pigeon" ; whale birds ; the Arctic tern and white rumped terns ; the black-backed gull ; the pugnacious skua ; the blue-eyed shag or cormorant and the little sheathbill. The last is a timid, friendly little bird that readily winters if an exploring ship affords it adequate nutriment in scraps and refuse. Many of these birds are very tame and can easily be approached, for they have no enemies which prey upon them.

The ice covering over nearly the whole continent precludes the possibility of insect life such as occurs in the Arctic. The only representatives of a land fauna are a few small ticks, water bears and microscopic rotifers, which live in moss and freshwater lakes. During the greater part of the year their homes are frozen solid and yet they survive and are active in the few days of summer. James Murray experimenting with water bears and rotifers found that they survive temperatures of  $-40^{\circ}$  F. and  $+200^{\circ}$  F., an exhibition of vitality probably unique except among unicellular organisms. The rotifers belong mainly to species of a wide distribution throughout the world which points to recent immigration to the Antarctic. Long isolation in the peculiar environment in which they are found would almost certainly have led to the evolution of new species. Their extraordinary vitality no doubt makes their transport possible on the feet and plumage of birds, embedded in scraps of soil and moss.

As in the Arctic there is a wealth of life in the sea. The appearance of barrenness afforded by the lack of life in the rock pools at low tide is due merely to the destructive action of ice. A few fathoms down the waters teem with life. A single instance will illustrate this. The *Scotia* in 1903 lay ice-bound in 10 fathoms in Scotia Bay, South Orkneys. Practically every day for seven months a haul of the dredge was taken over the bottom of the bay for fifty yards, on an endless rope arranged in position before the floe consolidated. Not on half a dozen occasions did the dredge fail to bring up a haul of marine life although exactly the same track was scoured day after day. As in the Arctic this wealth of life which is found at all depths

must eventually be linked with the extraordinary vigour of microscopic plant growth in the surface waters.

When little was known of the Antarctic fauna except from the collections of the *Challenger* made in a hurried visit, an ingenious theory of bipolarity was invented by H. Théel and supported by G. Pfeffer and Sir J. Murray, though the evidence was weak. The theory stated that polar faunas, north and south, are more nearly related to one another than to the faunas of intervening temperate seas. It was based on a very few cases in which the distribution was imperfectly known. In one group after another, in which evidence of bipolarity had been found, further knowledge has dispelled the belief. Examples taken from various divisions of the crustaceans, molluscs, echinoderms and other groups have all proved fallacious. In the plant world bipolarity was at one time found among oceanic diatoms: now only a single bipolar species is recognized. The northern and southern floras, on improved knowledge, have turned out to be almost completely different. The theory of bipolarity is exploded, and though certain forms show convergent adaptations to similar physical conditions, close genetic relationships do not occur between Arctic and Antarctic. Those forms which the two regions have in common are cosmopolitan species. There are even wide divergences between the marine faunas of different sides of the Antarctic continent which furnishes a proof, if proof were necessary, of the non-existence of a trans-continental strait.

There can, of course, be no question of stock-raising in the Antarctic continent, but on several of the sub-Antarctic islands experiments in this direction have met with greater or less success. As long ago as 1893 the Governor of the Falkland Islands prepared to investigate the pastoral possibilities of South Georgia, but by lack of funds the project came to nothing. In 1905 the South Georgia Exploration Company landed some ewes which lambed successfully, but the attempt was abandoned the same year, the ewes and lambs being left behind. Apparently they all perished. The vegetation is scattered: there are low-lying areas near the coast with plenty of tussock grass. Other grasses occur but they also are stiff and coarse and make poor pasture. Moreover, there are many peat bogs and the interior is mountainous, ice-bound and

inhospitable. Sheep would soon exhaust the slow-growing grass and, if they survived the summer, would certainly perish in winter. Goats might have a better but yet doubtful chance of success. Three mares and a stud horse introduced in 1905 ran wild and survived for many years. Rabbits have been unsuccessfully tried, but unfortunately the brown rat has thriven and multiplied for a century, preying on eggs and young birds as well as eating tussock grass. Most interesting are the experiments that have been made to acclimatize reindeer from Norway. Buck and does introduced in 1911 and 1912 increased in a few years to several small herds, but there is a lack of feeding for large numbers. Suggestions have been made to start Arctic fox and musquash farms: they might succeed, but only at the expense of the penguins and other birds. Moreover, South Georgia might prove too wet and even too mild for the winter pelt to grow to its best and more valuable condition.

Kerguelen is less mountainous and glaciated than South Georgia, and there are stretches of coarse meadow grass and vegetation is by no means scanty, although much of it is peat bog. Though very wet it is never cold. Snow lies only a few days at a time and frost is rare at sea-level. In 1913 about a thousand sheep were taken to Kerguelen and left in charge of three shepherds. This attempt was no more encouraging than earlier ones: of a flock of 20 landed in 1909 only 13 survived five years later, and none had been born, while of another flock of 20 landed in 1911 five died in three years. Yet the experiment was tried again in 1923. Kerguelen is clearly unfitted for sheep. Reindeer have not been tried, and the climate is not cold enough for successful Arctic fox breeding.

## CHAPTER XV

### THE ESKIMO

**M**ANY races touch the Arctic regions towards the northern limits of their expansion, such as the Samoyedes and Lapps in Europe, the Ostyaks of Yenisei, Koryaks, Yukaghir, Tungus, and particularly the Chukchee in Asia, but the only race whose habitat is confined, or very nearly confined, to Arctic regions is the Eskimo or Innuut.

The Eskimo inhabit the coasts of North America from the Bering Sea to the west coast of Greenland and Labrador. A few live on the east coast of Greenland and a few on the Siberian side of Bering Strait. In Canada their chief homes are in the Barren Lands and on the coasts between Coronation Gulf and Hudson Bay, Melville Peninsula, Baffin Island and Victoria Island. Formerly they also lived on Banks and Melville Islands, North Devon, Ellesmere Island and all along the east coast of Greenland. There have never been Eskimo on the islands of the Asiatic or European Arctic.

Throughout their domain the Eskimo are of the same race and speak the same language. Any differences that occur are merely differences of dialect. They are a dolichocephalic people with a cephalic index of about 72 and below the medium height but not really small, their average stature ranging from 5·4 feet, on Coronation Gulf, to 5·2 feet around Hudson Bay. In appearance they are generally pale brown or sallow, with small slanting brown eyes, small flat noses and broad rounded cheeks. The hair is black and straight. An anomalous tribe are the so-called blonde or copper Eskimo whose recent discovery gave rise to many sensational stories. D. Jenness, who made anthropometric measurements and other records of these people, holds that in spite of a few abnormalities in hair, eye colour, stature and appearance, which are not unknown in other

Eskimo tribes, the blonde Eskimo do not merit their name, and that they are as pure as the purest known branch of the Eskimo race of whom definite and detailed knowledge is available.

The entire Eskimo race is estimated by Rasmussen to number not more than 33,000, of which perhaps 14,500 live in Greenland. Of the Greenland Eskimo, or Greenlanders as they prefer to be called, the great majority have some trace of European blood, except the 240 on Smith Sound and perhaps the 640 on the east coast. In Siberia there are 1,600 Eskimo and in Labrador only 1,000. The last census of Canada includes only 3,270 Eskimo, which is probably an underestimate.

Even allowing for exaggeration in the generally accepted estimates of the difficulties of contending with great cold, and the poverty of Arctic resources, the environment in which the Eskimo live is one that demands and has produced amazing adaptations and adjustments not called for elsewhere on the globe. His food he obtains almost solely by hunting, chiefly in the sea, with weapons made of bone in the general lack of wood or metal, using frail boats of skin stretched on frameworks of bone and sewn with sinews. Vegetable food is practically denied him. For clothes, having no fibres, he must use skins. Shelter, which is so essential for climatic reasons, must be built of stone, peat, bones or snow. Warmth can be found only in oil melted from the blubber of sea mammals. Natural productions are few and each is utilized to the utmost of its possibilities. Life is hard and calls for endeavour, ingenuity, foresight and mutual co-operation.

In spite of all his difficulties, the Eskimo have succeeded in reaching a state of normal prosperity and well-being with great happiness and a light-hearted acceptance of their destiny. They are the freest people on earth.

Many an explorer of the past, dismayed at the cheerless prospect around him, has described the Eskimo as miserable beings and assumed that they have been driven by competition to their polar fastnesses which no other race envied them. Missionaries also have not infrequently drawn sombre pictures of Eskimo life, but, as V. Stefansson says, "some missionaries are so deeply religious in the orthodox sense that they are

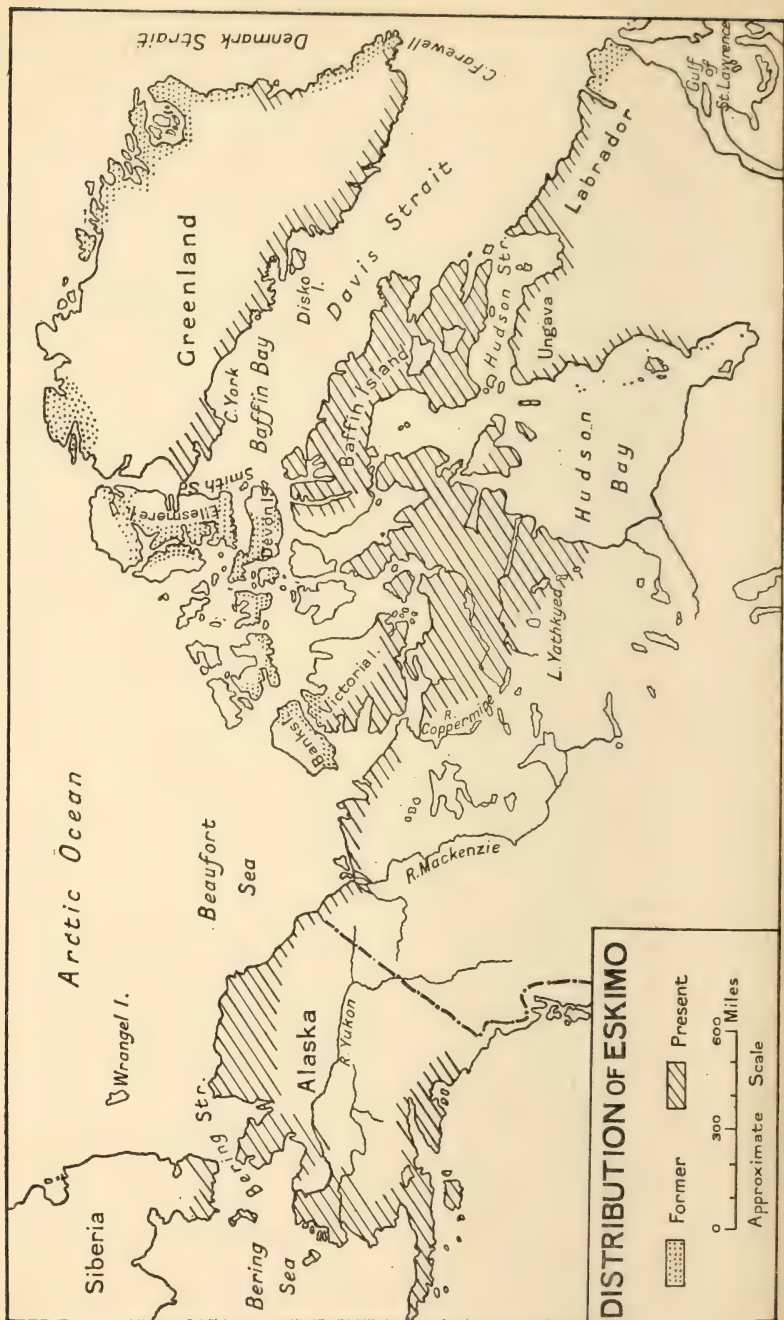


FIG. 13

constitutionally incapable of conceiving that anyone can really be happy unless he has been ' saved. ' ”

The main Eskimo culture to-day is a coastal culture depending, at least in winter, on seals. And the regions frequented are those favourable to seal-hunting in winter. On shores exposed to strong currents ice forms tardily or not at all in winter, and such shores are avoided by the Eskimo. Stefansson points out that a lack of seals no doubt accounts for Eskimo avoiding Melville Island nowadays. On the other hand, there are the inland tribes of Eskimo who never engage in seal-hunting. They are dependent on caribou and live where they are plentiful all the year round. Even the coastal tribes frequently move in summer to inland hunting grounds. Rasmussen has pointed out that the Eskimo, where they have the choice, differentiate between the flesh of musk-ox and caribou, and the flesh of seals and whales. Land animals are less rich in fat and so less warming in a climate where warmth is generally needed : they are looked on as supplementary food rather than staples. Another contrast in favour of sea mammals is that from them an abundance of oil can be obtained, which is the sole source of light and warmth in the winter hut and of fuel for cooking. The inland Eskimo of the Barren Lands have unheated huts and only a little heather for cooking, while the inland Alaskan tribes are so appreciative of seal blubber for oil that they buy it from the coast tribes. The fat on caribou and musk-ox is so little compared with that on seal that an enormous number of animals would need to be killed in order to procure adequate oil. It is thus reasonable to suppose that once the Eskimo became acquainted with the resources of the polar sea they were loth to leave it, and their migrations were largely regulated by the supply of seals. Skilful as the Eskimo is in handling his kayak, it must not be forgotten that during a great part of the year the hunt is not by boat but over the sea-ice with sledges. Among the polar Eskimo the kayak can be used only for two months in the year, while further south in Greenland it is more serviceable and so better built and more ably handled.

The seal culture depending thus on fast winter ice and open, sheltered waters in summer, probably did not arise on open coasts which would prove distinctly discouraging. The west coast of Greenland with its belt of islands and sheltered fjords

would be an ideal cradle for the growth of maritime interests, but it was reached relatively late by the Eskimo, who already had developed their sea culture. Labrador is out of the question, Hudson Bay is unlikely, and the north coast of Alaska scarcely suitable. There remain the middle regions of the Eskimo sphere, the sheltered channels to the north of North America. On geographical grounds that region is the most probable one for the development of the predominant Eskimo culture of to-day. Nansen has suggested that by intercourse with peoples on the Asiatic side of Bering Strait, the sea-faring Eskimo may have learnt the use of the dog as a draught animal, which is an Asiatic invention but now of vital importance to all Eskimo. Rink was less convincing in his suggestion that the kayak was originally an imitation of the Indian birch-bark canoe.

Of the two land animals on which Eskimo depend, the musk-ox not only has a narrower and more northern distribution than the caribou, but it is easier to kill, and many Eskimo prefer its flesh and fat. It is significant that it was probably by way of musk-ox lands that the Eskimo spread from the Arctic Archipelago through Ellesmere Island into Greenland. There is less sure evidence that following musk-ox they spread to the east of that island. Musk-ox cannot long survive in a region where Eskimo hunt extensively. A herd of them held easily by a few dogs is soon killed. On a large scale musk-ox and Eskimo would seem to be mutually exclusive. On Victoria Island the musk-ox have been exterminated by the natives, and as a whole the musk-ox territory to-day has a relatively small Eskimo population. Furthermore, it must be remembered that the great Eskimo migrations, even if they passed through musk-ox lands, moved along the coasts, that is to say, they kept in touch with seals. Owing to the far greater importance of the seal than the musk-ox to the Eskimo, it is likely that the distribution of seals was the deciding factor in Eskimo movements. Nowhere in the Eskimo domain are the musk-ox or caribou domesticated as the latter has been by the natives of the Old World tundras. Geese, ducks and other birds, which to many Eskimo are important in spring and summer, are also pursued at sea or near the shores, and are another inducement to keep the Eskimo on the coasts.

Previous movements of Eskimo are traced partly by records of travellers but mainly by "house places," tent rings, graves and abandoned sledge-runners of bone and wood, which practically never decay in the Arctic atmosphere.

When the Norsemen first reached Greenland in the tenth century traces of Eskimo were found, but the Eskimo certainly were not numerous on the south-west coast, if indeed they were actually present at that period. It is, however, incorrect to date, as often is done, the southward migration of the Eskimo as definitely later than the arrival of the Icelandic settlers.

Quite possibly the Eskimo or Skraelings (fairies or mythical creatures), as the Norsemen called them, were only temporary migrants to southern Greenland at first. Hunting tribes do not migrate in hordes and are always liable to be nomadic in their movements. Prehistoric remains found by Rink and others round Disko Bay afford proof that the Eskimo had moved at least that far south before the arrival of the Norsemen. It may have been due only to pressure of population in the north that eventually the Eskimo occupied the south-western coasts, inhabited by Norsemen. On the other hand, Nansen has suggested that the lack of mention of them in the sagas may have been due to the superstitious feeling that it was unwise to say anything about supernatural beings, as the Norse name implied.

The Polar Eskimo, that is the tribes on the Greenland coast of Smith Sound and Kane Basin, have, according to Rasmussen, a distinct tradition of a time when their area was crowded and population too numerous for comfort and food resources. The liability to many months of open water in the south would not favour seal-hunting, and may have discouraged settlement, when more favoured coasts were free. On the other hand, it has been suggested that the Eskimo spread southwards along this coast, following the sea as conditions became more Arctic. In view of the possibility of climatic changes this theory is not impossible (p. 47).

The east coast of Greenland has now no Eskimo except at the Danish trading station of Angmagssalik and the tentative settlement at Amdrup's Harbour on Scoresby Sound, but along the whole extent of the east coast there are traces of former settlements. In 1823 Clavering found two families as far

north as lat.  $74^{\circ}$  N., and half a century ago there were sixteen inhabited places on the east coast south of Angmagsalik, with a total population, including the latter place, of about a thousand.

Steensby and others have contended that the Eskimo reached the east via the north coast of Greenland, taking the same route that was followed by musk-ox; but this theory is denied by Rasmussen, who holds that the weight of evidence, now that northern Greenland is explored, entirely refutes it. On the whole of the north coast from Thank God Harbour in lat.  $81^{\circ} 38'$  N. along a stretch of 600 miles to Independence Fjord there is not a single sign of a tent ring, and from Benton Bay or Kane Basin to Sophus Müller Point on the east coast, a distance of 1,000 miles, there are no signs of houses. These facts alone dispel any likelihood or even possibility of Eskimo having rounded the north of Greenland. But furthermore Rasmussen insists that the conditions for travelling and hunting along that coast are so bad that no Eskimo would ever have attempted it. He does not deny that small herds of musk-ox may have passed that way, but he is certain that Eskimo could not procure food by that route. Eskimo who travelled with him agreed in this belief. A short cut across the barren inland ice is one that would never appeal to an Eskimo travelling with his family. The migrations to the east coast must have gone by Cape Farewell and spread northward, ceasing as those coasts which offered little inducement for seal-hunting were reached.

The origin of the Eskimo has been much debated. It is a problem that can be attacked from either a physical or cultural basis, that is to say their race relationships or biological descent may be traced or the geographical conditions in which their culture could have evolved may be studied. Physically they are related to the Amerinds or North American Indians, and it is now generally accepted that they are descended from an inland people who were led to the Arctic coasts either by following herds of caribou or pressure by hostile Indian tribes. Though Stefansson holds that Indians are more frightened of Eskimo than the reverse, the extreme timidity of unsophisticated Eskimo and the pervading idea in their traditions that strangers are hostile, may not unlikely be derived from long past un-

successful contests with stronger tribes. H. Rink made a serious contribution to the subject when he traced the Eskimo from the interior of Alaska and derived their sea-culture from a river-culture. By descent of rivers he believed that the Eskimo eventually spread to the Arctic coasts from the Indian tribes from whom they sprung. But in the light of later research and more detailed knowledge of Eskimo tribes, unknown to Rink, another theory has more evidence in its favour. H. P. Steensby traces the Eskimo from an inland people living in the Barren Lands around the Great Slave Lake to the west of Hudson Bay. There lived the Palæo-Eskimo with an Indian hunting culture which was gradually adapted to a sea-hunting culture on the shores of Coronation Gulf. Thence east and west, to Greenland and Alaska, spread the Neo-Eskimo culture as it exists to-day.

The latest and more extensive researches on Eskimo migration were made by K. Rasmussen and his companions, who travelled the whole extent of Eskimo territory from east to west. Rasmussen's conclusions are in accordance with Steensby's theory: modifications are merely in detail. He finds the oldest Eskimo culture (Proto-Eskimo) represented in the Caribou Eskimo, inland dwellers on the Barren Lands west of Hudson Bay around Lake Yathkyed. They are independent of the sea, living mainly on caribou, except for some trout and pike from the summer streams. In their isolation, on the road to nowhere, these Eskimo have retained much of their pristine culture. From their inland home the Eskimo spread northward to the coast of Coronation Gulf, one large group alone remaining inland in the Caribou Eskimo of to-day. Then developed the Palæo-Eskimo with the Thule culture, which was once homogeneous from Greenland to Alaska, was based on the hunting of sea mammals and entailed permanent winter houses of bones, stone and turf grouped together in small settlements. It is still found in isolated parts as around Cape York, whence it derives its name from the trading station at Thule, and on Point Barrow. Both Steensby and Rasmussen trace the development and perfection of this old culture on the shores of Bering Strait where not improbably it received external influences from Asia which added to its technique. There in the open sea the hunting of whale and walrus from

skin boats developed to a state of perfection. This Neo-Alaskan culture spread again eastward, influencing all the coastal tribes through the North-West passage, in Baffin Island, Hudson Bay, Labrador and Greenland. Finally in recent times a new migration set in from the interior to the coast in the central area, an offshoot of the Proto-Eskimo culture, both by actual migration and by cultural drift. Hence the mixture of land and sea culture found among the central Eskimo to-day, the coastal seal-hunting in winter and spring and the nomadic land-hunting in summer and autumn. This latest culture is characterized by lack of permanent settlements, by snow houses in winter, and by changes in weapons, lamps and cooking-pots. Stefansson comments on another coastward migration due to the decrease in the number of caribou : that is in Alaska where the use of fire-arms during the last half-century has wrought havoc among the wild caribou. This has forced the Eskimo to the coasts, where, moreover, conditions of life grew easier through the white man employing natives in the whaling industry.

Since Stefansson's and Rasmussen's journeys of recent years there are probably no Eskimo tribes that have not come in contact with white men, and there are few that retain unchanged their endemic culture. The Copper Eskimo around Coronation Gulf, in spite of their use of native copper from the Coppermine River and Victoria Island, were in 1914 virtually in the Stone Age in other respects, using bow and arrows and copper knives and fish-hooks. The Caribou Eskimo whom Rasmussen found in 1922 at Lake Yathkyed knew practically nothing of white men. Though Eskimo are scattered, as a hunting people must be, there can no longer be any so isolated as the Polar Eskimo who, when J. Ross found them at Cape York in 1818, believed themselves to be the only people on earth.

Contact with the white man has come mainly by way of fur hunters and whalers, except in Greenland, and has been a mixed blessing. It has certainly given the natives better weapons for the hunt, but better weapons mean more effective hunting. In five years, after opening trade relations, the Copper Eskimo abandoned bows and arrows for rifles, stone vessels for iron pots, and skins for canvas boats. The use of

fire-arms has decimated the caribou in Greenland, the Mackenzie delta, Alaska and elsewhere, and so reduced food resources and decreased well-being. The white man has also introduced new wants—tea, tobacco, sugar, soap and other less useful commodities. To acquire these the Eskimo sells skins which he ought to keep for adequate clothing, and hence the appearance in places of natives too scantily clothed for the winter cold. Stefansson noted this in the Mackenzie delta, and commented on the lack of skins for building kayaks among the Greenland Eskimo. W. T. Grenfell, many years ago, described the Eskimo of Labrador as dying out. Their contact with the white man has for long been extensive, and the use of the rifle, the steam whaler and other improvements in hunting, by decreasing the number of seals and virtually exterminating the walrus, have worked havoc with native food resources.

During the Great War the customary European supplies in Greenland ran short : to the far north no ship came in 1917. The result was that the Eskimo had largely to revert to primitive methods such as were employed before the white man brought them fire-arms, knives, tea, matches and so forth. And they fared badly, for the old arts had been forgotten in the easy dependence on imported goods.

Care is taken by Denmark, Canada, Newfoundland and the United States, who control all Eskimo territory, that spirits are not introduced. But the advent of the white man has left a trail of diseases from which many tribes suffer badly. In the year 1734-5 no less than 2,000 Greenlanders died of small-pox, and to-day tuberculosis is rife. Denmark wisely closed all Greenland ports to foreign vessels many years ago to stop further contamination, but in the Mackenzie delta Stefansson tells a sorry tale of whalers' influence. There he found in 1913 a population had decreased in sixty years to 3 per cent of its former total, and the remnant showed much illness and insanity, due largely to syphilis. At Cape Bathurst he found forty "civilized" Eskimo, of which twenty were seriously ill and two insane. Among "uncultured" Eskimo less than 1 per cent suffer from any illness. The native population of Greenland which for many years was practically stationary is now said to be increasing under the wise care of the Danes.

The Hudson's Bay Company is trying to start new industries

near their northern trading ports, and the Canadian Government is exercising parental care through its far-flung police posts and Eskimo reserves (p. 170), but it is doubtful if the Eskimo will survive in the long run. As the white man penetrates their fastnesses, brings his ways of living, his food, and his habits with him, the Eskimo lose their own culture and old-time skill in fighting adverse climatic conditions. They become more and more parasitic on the white invader. Hope of their persistence might lie in the probability that white settlers will never invade the greater part of the Arctic hunting grounds where the Eskimo will have no real rivals. But the excessive hunting, with modern weapons, in response to the traders' demands and as an outcome of the Eskimo's new found love of the white man's trade goods, mainly useless to an Eskimo, is reducing game even in the remotest Eskimo domains at an alarming rate. The spread of trade means economic enslavement to white man's civilization and eventual extermination. Traditions and language still remain, but many Eskimo have already adopted or given a nominal adoption to the white man's religion.

## CHAPTER XVI

### WHALING: NORTH AND SOUTH

THE Norsemen made many Arctic discoveries, possibly more than records tell, but except for Greenland, they found the north unattractive. It was several centuries after their great era of voyaging that the Arctic entered the field of commerce. Significantly it was the gulf of warmth that stretches northward into the eastern Greenland and the Barents Seas that first led men on. Barents' rediscovery of Spitsbergen in 1596 soon resulted in a flourishing whaling industry on its western shores.

In those days the chief, if not the only, whalers were the Basques and other people round the Bay of Biscay. They hunted the Biscayan or Atlantic right-whale, and had done so at least since the eleventh century. The Dutch were interested only in stranded whales, and many early references to whaling, as off the coasts of Norway, may refer not to whales at all, but to walrus. By the fifteenth century a scarcity of whales had led the Biscayans to Icelandic and Newfoundland waters. Dutch and English, probably with Biscayan harpooners, then joined in these northern "fisheries," so that the Muscovy Company was able to find men acquainted with Arctic conditions, if not expert whalers, early in the seventeenth century, when they led the way to the Spitsbergen whaling.

The chase was for the Greenland right-whale or bowhead (*Balaena mysticetus*), and perhaps also for the Biscayan whale, which certainly finds its way to northern waters. At first the baleen or whalebone alone was taken, but later the blubber was highly valued for oil for lighting and soap-making. In those days a state bounty was paid to whalers. For many years the industry thrived in Spitsbergen bays, with busy boiling stations ashore, and led to keen rivalry and even warfare between English, Dutch, Danes, Basques and Ham-

burgers. The year 1697 was a record year in the whale fishery, and there were 200 whalers, of which over half were Dutch, in Spitsbergen waters. In 1701 there were 207 Dutch ships as well as others in the north. Gradually, however, the onslaught on the whales robbed the coastal waters and the bays of their value and the whalers had to pursue their calling in the open waters of the Greenland Sea where there was room for all. The Greenland Sea whaling persisted throughout the eighteenth and the early nineteenth centuries, when Norwegians also joined in the fray. Then British whalers, discontented with small catches, moved farther west to the Davis Strait fishery. The introduction of steam into the old wooden vessels made this longer journey comparatively easy and quick. Another innovation was the harpoon gun which replaced the old hand harpoon. Every summer by the middle of June the Scottish and a few Dutch whalers used to fish off Disko Island. In later years when that locality failed them the whalers pushed farther north. They crossed Melville Bay to the North Water in early summer, and then to the mouth of Lancaster Sound and turned southward, following the "running" of the whales, eventually leaving for home towards the end of October. A few vessels, chiefly American, wintered in Cumberland Sound, and now and then one was involuntarily detained by ice. As time went on the "Old Greenland" fishery, of the Greenland Sea, attracted fewer and fewer vessels, and these were mainly from Norway, Holland and Germany, with a few Scottish ones among them. Most whalers left home in February and went north to the seal fishery on the pack-edge between Jan Mayen and Spitsbergen, returning about the end of April. In the beginning of May they left for the Baffin Bay or the Greenland Sea whaling and came back from the former in November, but the latter as early as September. At one time the profits were very considerable. In 1820 Hull sent out 62 ships to the Old Greenland whaling, which between them brought home 8,000 tons of oil and whalebone of a total value of £240,000. From 1788 to 1879 the total number of right-whales taken by Scottish whalers was 8,415. The value of the oil fell as mineral oil and gas were used for illuminants, and vegetable oil for many purposes, but as oil fell so did the price of baleen rise. Hence the chase concentrated almost solely for the right-whale with

its long and heavy "bone." By the end of the nineteenth century, with bone £2,000 a ton, one whale showed a profit for the voyage.

In this whaling, shore stations were not used. The blubber was "fensed" and made off at sea and brought home to be boiled down for oil. It was a dangerous calling and became all the more so when it moved to Baffin Bay. Many ships were lost in "taking the ice" in Melville Bay and others were nipped off Baffin Island. Between 1772 and 1852 Hull lost 80 out of 194 whalers belonging to the port. Melville Bay accounted for 14 ships in 1819 and 19 in 1830. And yet there was seldom heavy loss of life. As the ice closed in and crushed the ship, the men walked over the pack to other vessels. Sometimes, however, a vessel was caught and separated from the rest of the fleet, and then the danger was considerable. Even if the ship were not lost the weary drift might last for months, till rations were very low and the crew were sorely stricken with scurvy. The long drift of the *Diana* of Hull, which is described by the surgeon on board, may be taken as typical, with the steady inroads of scurvy, the threat of starvation, and the ebbing of hope as the terrible months went by.<sup>1</sup>

The right-whale was nearly hunted to extinction, and by the eighties of last century the number of whalers was quickly diminishing. Dundee was the last Scottish port to maintain Arctic whalers, probably because whale-oil is much used in certain jute manufactures. Hull ceased as long ago as 1868. The end came quickly through the invention, about 1905, of a commercial substitute for whalebone. When bone dropped to about £100 a ton, a whaling voyage without the certainty of a "full ship" was doomed to financial disaster. Dundee had twelve whalers in 1867, ten in 1905, and only five in 1909. Davis Strait had then been given up and the Greenland Sea yielded a total of only fifteen whales, big and small. The previous year the total taken by four vessels in Davis and Hudson Straits was only four whales. By 1914 the Dundee whaling industry was dead and the last of the ships, the famous Antarctic exploring vessels, *Balaena* and *Scotia*, were lying forlorn, awaiting improbable purchasers.

A temporary revival in Spitsbergen whaling took place early

<sup>1</sup> *From the Deep of the Sea.* See References.

this century owing to whaling being forbidden on the coasts of Norway. A few bad cod seasons confirmed the Norwegian fishermen's belief that the destruction of whales was responsible for the failure. Their contention was that the whale pursues and feeds on the capelan, which in its turn pursues the cod inshore: the destruction of the whale led to no cod reaching inshore waters. Some small finners feed on capelan, but the blue whale does not. However, the anti-whaling agitation became so fierce that the Government had to bow before it. At first there was a prohibition against whaling within one mile of the coast from January to June, and this was followed by a complete prohibition of all whaling in the territorial waters of northern Norway.

The whaling of that period was of a new type. It was concerned mainly with rorquals or fin-whales, that were hunted by quick-moving steamers armed with explosive harpoons. This kind of whaling originated in Norway and has remained almost exclusively in Norwegian hands. At first it was successful in Spitsbergen. In 1905 there were 16 whalers at Spitsbergen and Bear Island, and their catch totalled 599 whales, but by 1912 the catch with 6 whalers was only 55 whales, and in 1920 only 18 whales. After that the stations were abandoned. Successful whaling still takes place in the Greenland Sea by Norwegian whalers working up to the edge of the ice from shore stations in the Faroes and Iceland. There have also been stations in the Hebrides, Shetland and Newfoundland since the whalers were driven from the coast of Norway.

Alaskan whaling did not begin till 1848, and largely due to the failure of the New Zealand fishing, it soon grew to great importance. The whalers were mainly from New Bedford, with a few latterly from San Francisco. After hunting sperms in the Pacific they made for Bering Sea in April and took the first chance of going through the straits, watching for the right-whales in their migration northwards. Ships went east along the coast to Point Barrow, and in the autumn turned west along the edge of the pack towards Herald Island and the Siberian coast. In October they left the Arctic unless, as sometimes happened, they were caught in the pack, or voluntarily wintered. There was a time when 300 whalers passed

Bering Strait every year. Of course this slaughter worked sad havoc, although the whalers attributed failure to the introduction of steamships, which, they held, frightened the whales. For some years the industry was more successful further east, and from 1889 Herschel Island became the great Alaskan whaling centre. The ships generally wintered, ten to twenty of them, to be on the spot in early spring. For a few years fortunes were made, but by the early years of this century the industry was on the down grade for the same reasons that it failed in Greenland. In 1915 only five whalers, caring only for oil and not for bone, visited the Alaskan coasts, and now there is none. Whaling paid a heavy toll in ships along that coast. When the ice came down suddenly from the north, ships were caught and driven ashore. In 1876 thirty-six ships were crushed off Point Belcher and in 1879 several were caught and destroyed forty miles off Point Barrow with great loss of life.

The bottlenose (*Hyperodon rostratus*) is one of the smaller toothed whales. It lives on cuttle fish, herrings and other small fish. Generally it moves in herds of five or six or as many as a hundred, but old bulls, like those of other species, are often solitary. The blubber has the curious quality of being strongly aperient. Nansen points out that this is not a true Arctic whale, since it frequents mainly the waters between the warm and cold currents in the North Atlantic and keeps clear of the ice. After the young are born and the whales have mated they move south to warmer waters. The bottlenose has never been much hunted except in the eighties and nineties of last century, when Scottish and Norwegian vessels took big catches off the Faroes, Iceland and in the Barents Sea. It is said to be difficult to kill but not dangerous, and could certainly be successfully hunted with modern whaling weapons.

Eskimo hunting accounts for few large whales. The chase of the right-whale has been almost abandoned, but for many years was a staple industry in Greenland and Cumberland Sound, natives being employed by Europeans and using European boats and weapons. Humpback whaling was more peculiar to the Greenland Eskimo; but has almost died out. Rink, half a century ago, put the annual catch by the

Greenland Eskimo at not more than four large whales a year.<sup>1</sup>

Whaling stations at Kekerton and at Blacklead in Cumberland Gulf, Baffin Island, were for many years controlled by Dundee and Aberdeen owners but manned by Eskimo. For profit they depended on whales, but collected also a number of furs. Other stations as at Ponds Bay, Repulse Bay and elsewhere are owned by the Hudson's Bay Company and are mainly fur-hunting stations.

The Alaskan Eskimo, using boats and weapons supplied by the white man, did better hunting. When the price of bone was high, whaling stations in Alaska manned by Eskimo made huge profits, but that, too, is all over. Incidentally the boom on the Alaskan coast brought material prosperity and some of the amenities of civilization to the Eskimo, but it did not enhance their moral standards. Off the Siberian coast, the only whaling is by Eskimo on Bering Strait.

Another species of right-whale (*B. australis*) is found in the Southern Ocean and used to be hunted around New Zealand, Kerguelen and the Falkland Islands, for whalebone and oil. In the eighteenth century British and Spanish whalers had bases in the Falkland harbours of Port Egmont and Port Desire. The number of ships, especially Americans, grew in the early nineteenth century when they frequented also South Georgia. Kerguelen, with its fine harbours and ice-free seas, was a particularly busy southern outpost of the American ships for many years. Early this century French and Norwegian whalers, with leases from France for shore stations, tried with no great success to revive an industry that was doomed for lack of whales.

The Auckland Islands were selected in 1847 as the site of an ambitious project for whaling, when the well-known whaling firm of Enderby obtained a lease of the islands from the Crown with the title of Lieutenant Governor for Mr. C. Enderby. A settlement was formed and hopes ran high but their fulfilment was not forthcoming. In a few years the project was abandoned.

<sup>1</sup> This does not include narwhal, white whale, and small species of cetaceans.

It is said that between 1804 and 1817, the great days of southern whaling, American ships alone took 193,000 right-whales. Like the Arctic whalers these southern ships took any kind of whale that came to their harpoons, but finners were outside their scope. Their chief quarries were the right-whale and humpback, but they were eager to get valuable sperms. In fact, many of them were really sperm-whalers passing to or from the tropical whaling grounds. The sperm (*Physeter macrocephalus*) is not truly a polar whale, and prefers the warmer sea, but occasionally wanders into high latitudes, north and south.

When the Greenland whaling showed signs of exhaustion, the Scottish whalers began to look for new grounds. This led to the Antarctic expedition of the Dundee whalers of 1892-3. Fifty years earlier Ross had reported whales in Erebus and Terror Gulf, Graham Land. From his description these seemed to be right-whales. Four whalers from Dundee and one from Norway sailed south to try their luck. From a commercial point of view the expedition was a failure. No whales were captured and no right-whales seen. To reduce their loss the ships filled up with cargoes of seal-oil. But plenty of finners were seen, which in the lack of guns and suitable gear could not be attacked. As W. G. Burn Murdoch put it, "One might as well have tried a dry-fly for the Scottish express." Attempts to arouse interest in hunting these whales failed in Scotland, and even in Norway met with no response for some years. A search in the Ross Sea for right-whales in 1894 also ended in failure. The invention of the explosive harpoon in 1867 by Sven Foyn had long before this made finner-hunting possible. Its success in the north has already been noted. Not, however, till a chance brought C. A. Larsen to the limelight in Buenos Aires did this industry start in the south. It was largely accidental. Larsen was captain of O. Nordenskjöld's Antarctic expedition, which was wrecked off Graham Land. The ship's company was rescued by an Argentine corvette and brought to Buenos Aires. Larsen was the hero of the hour: his words carried weight. When he suggested a whaling venture the capital was soon subscribed and an Argentine company started in 1904 with a base in South Georgia. It might have occurred ten years earlier if British

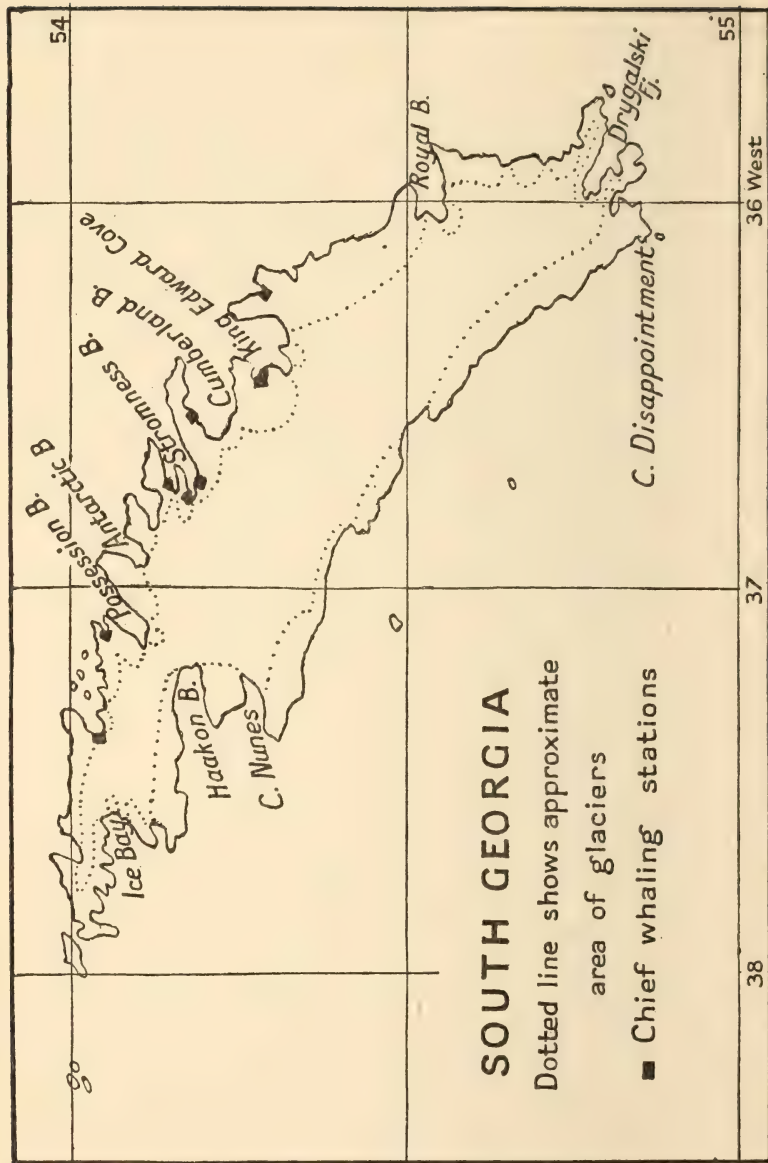


FIG. 14

capitalists had had a little courage and imagination. Since its start the industry has had phenomenal success. In 1915-16 as many as 11,792 whales were captured in the waters of the Falkland dependencies; in 1921-2 the number was only about 7,000, the decrease being due partly to fewer whalers and partly to overhunting. There are now five land stations at South Georgia and floating stations, withdrawn in winter, at the crater harbour of Deception Island in the South Shetlands. Norwegian, British (Leith) and Argentine companies are at work, but the men employed are practically all Norwegian. The steam whale-catchers, small vessels of about 100 tons, work far afield towing their whales to the stations. For a year or two the South Orkneys also had a station and licences were granted, but not used, for the South Sandwich Group. At New Island in the Falklands there was a whaling station for a few years. The hunting season is now limited by law to the period from September 16 to May 31. In winter the whale-catchers lie in South American ports while the mother ships, or floating factories, and carrying steamers go to Europe. The whales hunted are the humpback (*Megaptera boops*), the fin-whale (*Balaenoptera physalis*) and the blue whale (*B. musculus*). A few right-whales, sperms and seiwhal (*B. borealis*) are also caught. These are the same whales that are now hunted in the north Atlantic. The humpback, which is relatively easy to harpoon, used to account for over 96 per cent of the total catch: now it represents less than 10 per cent. The whalers attribute the decrease in humpbacks, first to its timidity, which has caused it to migrate to other seas, and secondly to the increased attention that they pay to the larger and so more valuable blue and fin whales. These explanations may have some weight, but it is difficult to believe that diminution in numbers is not the chief cause of the decrease. All the whales are hunted chiefly for oil, which averages about 85 barrels, or 14½ tons per whale, at about £30 per ton. In 1924 the export of oil was 458,000 barrels. Whalebone, whalemeat and guano are by-products, though whalemeat has little market except in Japan. The meat from South Georgia is made into meal which is used for cattle-feeding.

In order to investigate the many unsolved problems with regard to whales, their food, migration routes, breeding,

number, etc., the Falkland Islands Government has set aside the revenue from the licence fees and export tax on oil as a research fund. In 1925 it had reached over £300,000. This sum is being used on the R.R.S. *Discovery* and the whaler *William Scoresby* which, together with a scientific station on South Georgia, are to be maintained for at least three years' marine research, a project that cannot fail to throw light on the problems of the whaling industry as well as add greatly to scientific knowledge.

Captain C. A. Larsen, not content with his success at South Georgia, turned in 1923 to a new venture, obtaining from the New Zealand Government a five years' monopoly of the Ross Sea. With a floating factory and five whale catchers he worked off the Ice Barrier. Blue and fin whales were plentiful and a cargo of 17,500 barrels of oil was secured, by no means a poor return, though Larsen had hoped for 50,000. No right-whales nor humpbacks were seen. The following season, during which Larsen died in the Ross Sea, the yield was 32,000 barrels from 427 whales.

## CHAPTER XVII

### POLITICAL GEOGRAPHY

**F**ROM the earliest days of polar exploration territorial claims have been made from time to time, but as often as not without authority. Annexation by private persons is null and void. To be valid it must be an Act of State. Unless performed by officers commissioned for the purpose it must be ratified by the State concerned, or it has no significance.

Pride of discovery and triumph of attainment have been the chief motives in flag-hoisting in the past, strategic considerations have seldom weighed and economic interests are motives of recent date. Colonization has played a very minor part even in Arctic Canada, Greenland and Spitsbergen: elsewhere in the Arctic it has not occurred. The criteria of ownership of uninhabited lands are not settled and, by the nature of the problem, are difficult to decide. No law can be cited, and precedents which would seem to underlie international practice are too contradictory to be a useful guide. Many instances could be given to show that discovery and exploration do not in themselves constitute a title to ownership. It has been argued that by international usage annexation without settlement lapses in five years' time or, at any rate, that settlement if not continuous must be intermittent, and that entire abandonment for a considerable time nullifies ownership. But literal acceptance of a rule of this kind would lead to many disputes. For instance, what area is to be considered a unity? Does settlement of one island constitute a valid claim to a whole scattered archipelago? Does the utilization of one spot on a coast entail the sovereign right to a great island or long stretch of mainland? If there were more competition for the sovereignty of polar lands these problems would require to be solved. In practice they have little but academic interest.

Arctic lands are in the main northward prolongations of temperate inhabited regions, in many instances discontinuous prolongations, but all the same clearly in close relationship with the nearest mainland. Several have fallen under the sovereignty of the adjoining mainland States by natural growth of territorial interests. This is notably the case with regard to Russia and Canada and less so with Norway. But there are exceptions and instances of lands which present peculiar interests in political geography. Russia, as perhaps the earliest Arctic power, may be considered first. From Kolguev and Novaya Zemlya eastward to Herald Island, with the exception of Franz Josef Land, all islands in the Arctic Ocean have been considered Russian, and Russian claims, except in Wrangel Island, have not been disputed. Kolguev, Vaigach and Novaya Zemlya are but detached portions of the mainland used only by Samoyedes and Russian traders. Novaya Zemlya indeed was colonized by the action of the Russian State. The other islands, if used at all, are visited only occasionally by Russian trappers or ivory hunters, though some like Henrietta and Herald Islands were discovered and annexed (1881) by Americans. In 1916 Russia reiterated her claim to all these islands at the time she announced that the new discoveries of Captain Vilkitski, Nicholas (Northern) Land, Alexis (Little Taimir), Vilkitski and other islands were Russian territory. The note specified as being an integral part of the Empire "les îles Henriette, Jeannette, Bennett, Herald, et Oujedinenia,<sup>1</sup> qui forment avec les îles Nouvelle Sibérie, Wrangel and autres situées près la cote asiatique de l'Empire, une extension vers le nord de la plateforme continentale de la Sibérie." On the arrival of Amundsen's *Norge* at Leningrad in April, 1926, the Soviet issued a decree claiming all lands and islands that might be discovered in the flight across the Arctic Ocean to the north of the Soviet coasts and lying between long. 32° 4' 35" E. and long. 168° 49' 30" W.

Wrangel Island presents a peculiar case which might well afford endless scope for argument in the airy realms of international law. Reported in 1823 by F. von Wrangel on the strength of native rumours from Siberia, it was not sighted

<sup>1</sup> This is the island generally known as Einsamkeit or Lonely Island, which lies between Novaya Zemlya and Nicholas Land.

until 1849 when Captain Henry Kellett, R.N., saw it but did not land. No foot trod its shores till Americans landed in 1881, unless the German trader, E. Dallmann, was there in 1866. V. Stefansson, believing the island to be of great value as a flying base, hoped to add it to the British Empire. He argued that by international practice it was No-Man's Land when he sent his expedition of occupation there in 1921; that occupation alone constituted a valid claim to ownership; and that as a result of lapse of time all previous claims had fallen to the ground. Moreover, he held that Russia, of all powers, had not a vestige of right to an island no Russian had set foot on until 1911. The Soviet protested against this violation of Russian territory. Stefansson hoped that Britain or Canada would support his action, but neither government showed any inclination to do so. Nor was there any official protest when in 1924 the Soviet Government vessel, *Red October*, visited the island, hoisted the flag of the Soviet Republic and removed the Canadian settlement. Since then a settlement of fifty Chukchee families, from north-eastern Siberia, and three Soviet officials has been formed on the island and there is mention of a wireless station. It may be assumed that the Russian claims to Wrangel Island are not disputed by any State interested in the island in the past. The vessel which carried the settlers in 1926 went on to Herald Island and hoisted the Soviet flag.

In 1924 the islands of Novaya Zemlya, Kolguev, Vaigach, were for purposes of administration and colonization placed under the new Islands Administration of the Soviet Government which, in 1925, seeking some outlet for its authority, issued a prohibition of sealers, or other visits without Soviet permission. Russian patrol boats occasionally visit the coasts, but there are no regular communications.

Franz Josef Land was discovered by the Austrian expedition under J. Payer in 1873, explored chiefly by British, and visited infrequently by Norwegian hunters. In August, 1914, it was unofficially annexed by a Russian vessel. Perhaps it may be regarded as the last No-Man's Land in the Arctic, unless the comprehensive claim of the Soviet already referred to is intended to embrace it.

Although Peary hoisted the Stars and Stripes at the Pole,

the United States cannot effectively lay claim to a point in the ocean. The international practice of the recognition of the neutrality of the high seas rules this deed out of count as an act of annexation. By the Convention of 1867, when Alaska was purchased from Russia, the western boundary of Alaska was defined as "the meridian line of the 141st degree, in its prolongation as far as the Frozen ocean." There was no suggestion of claiming any islands that might, as far as knowledge went at that day, lie to the north of Alaska. Various airmen who proposed to fly across the Pole in 1926 made dramatic announcements of dropping this or that national flag on the Pole. Amundsen reduced these proposals to an absurdity, as far as claims to sovereignty went, by dropping the Norwegian, Italian and American flags.

Canada now claims, and to some extent exercises jurisdiction over, all the Arctic lands between the meridians of long. 60° and 141° W. of Greenwich, Greenland excepted. This would carry her sovereignty to the Pole if islands lay far enough north. The cession of territorial rights by the Hudson's Bay Company in 1869 brought its territories under the new Dominion of Canada, but it was not until 1880 that the Imperial Government granted to Canada all British territory in the northern waters of the continent of America and the Arctic Ocean between 60° and 141° W. and as far north as 90° N. These islands had become known mainly through the efforts of British explorers and many of them had been annexed at one time or another. The Franklin district of the North-West Territories, which includes most of the Arctic islands, covers about half a million square miles of land, or about one-seventh the area of Canada. The Canadian Government has been active in substantiating its Arctic claims. Annually in recent years a patrol vessel has gone north to explore, survey, annex and police the islands, levy taxes on whalers and traders and keep in touch with the Eskimo. Naturally the vessel can visit only a few places, but the police patrols make long journeys during the year. Police posts and post offices have been established from year to year at Pangnirtung Fjord on Cumberland Gulf, and at Ponds Inlet in Baffin Island; and at Craig Harbour and on Bache Peninsula in Ellesmere Island. Hunting and trapping are now reserved for Eskimo

on Banks and Victoria Islands and for Indians and Eskimo on certain areas on the mainland (Back's River, Yellowknife, Slave River and Peel River preserves), thus showing that Canadian jurisdiction in the north is more than nominal.

Danish sovereignty in Greenland used to be limited to the west coast between Cape Farewell and lat.  $74^{\circ} 30' N.$ , and the one settlement of Angmagsalik on the east coast in lat.  $65^{\circ} 30' N.$ , founded in 1894. In the far north and on the now uninhabited east coast, Denmark's jurisdiction was less than nominal until 1917. In that year Denmark transferred by sale the Danish West Indies (Virgin Islands) to the United States, and an integral part of the bargain was the renunciation of all American claims to any part of Greenland, claims that had a vague basis on Peary's discoveries in the far north. Denmark, in 1921, announced her sole sovereignty to the whole island and the closure of all its coasts to aliens. This aroused dissent in Norway since only Norwegian hunters visit the northern part of the east coast, and on their behalf Norway claimed that no impediment should be offered by Denmark. Norway, moreover, erected a wireless station at Mygbukten on the east coast (lat.  $73^{\circ} 30' N.$ ) in 1922 (p. 50).

The soundness of the Norwegian claim was indisputable, especially in view of Denmark's failure to make use of the east coast, except for Angmagsalik, and her policy of making Greenland a closed country. Moreover, Norway's traditions gave her a strong interest though perhaps no legal claim to a voice in Greenland affairs. Although the real exploration of the east coast has been done largely by Danes, the discovery of Greenland was due to the daring of Norsemen. Greenland was originally subject to Norway in the days of the early Norse settlements until communications with the mother country lapsed altogether (p. 196). When it was re-colonized in the eighteenth century, Norway was virtually a Danish possession. It was on these grounds that Denmark retained the sovereignty of Greenland on the dissolution of the union with Norway in 1814. By the Treaty of Kiel the King of Denmark resigned his sovereignty over Norway in favour of Sweden but exempted Greenland, Iceland and the Faroes. Norway did not at the time admit the validity of the treaty, but by the agreement of 1821 with Denmark

accepted the final settlement of all outstanding disputes including, at least by implication, the sovereignty of Greenland.

A few years ago feeling ran high in Norway and Denmark, although Norway disavowed any territorial claims in Greenland and held rather the view that eastern Greenland should be considered a No-Man's Land. The Greenland Agreement of 1924 between Norway and Denmark left undecided the principle in dispute, Denmark insisting on her undisputed right to all Greenland and Norway still declining to recognize this sovereignty. But it settled the practical issues and found a *modus vivendi* for the hunters in east Greenland. Along that coast from lat.  $60^{\circ} 27' N.$  to lat.  $81^{\circ} N.$  no restrictions are to be put on Norwegian vessels and hunters or occupiers of land except at Angmagsalik and around the new Eskimo settlements on Scoresby Sound (p. 198). The agreement holds until 1944. A similar concession was made to Great Britain.

Greenland is now governed from Copenhagen by *Styrelsen af Kolonierne i Grönland*, a section of the Department of the Interior and successor to *Den Kongelige Grönlandske Handel* (Royal Danish Board of Trade), which was founded in 1774. It has sole jurisdiction and a monopoly in trade. There are two provinces, respectively north and south of lat.  $60^{\circ} 40' S.$ , each under an inspector. Godhavn or Lively, as the old whalers used to call it, on Disko Island is the capital of the north and Godthaab of the south. The chief settlements or *kolonier* have Danish managers or *kolonibestyrer*. Some minor aspects of the government are now in the hands of district councils which are partly nominated and partly elected. There are no taxes and no police. There is no Governor-General of Greenland, but the Inspector for South Greenland takes seniority. The Director for Greenland lives in Copenhagen. The trading station at Thule on Smith Sound is under private control. Greenland harbours are closed to foreign ships except by permission or under stress of weather. This was done in order to protect the Eskimo from corruption and was a wise and necessary precaution. Exceptions on the east coast have already been noted, while recently the start of cod fisheries in Davis Strait by Norwegian vessels has led Denmark to open to foreigners the harbours convenient to Fylla Bank off Godthaab. The central idea of Denmark's rule in

Greenland seems now to be the care and well-being of the natives. In this aim it is successful, but it entails a yearly deficit of several thousand pounds in the administration.

With the exception of Eskimo the Vikings were the first men to visit Arctic regions. Yet Norway is the newest of all Arctic powers and only in 1925 entered on her domain in the archipelago of Svalbard (Spitsbergen). Vast resources of high-grade coal make this an important acquisition for Norway and a more generous gift than the politicians at Versailles realized. In spite of annexations by more than one State and occupation of mining estates by the subjects of several, Spitsbergen was regarded as a No-Man's Land when, in 1914, an international conference met to decide on some form of government. Russia refused to admit German representation on a joint commission of control and Germany pressed for more voice in the commission than her interests could possibly justify. A deadlock was reached when the outbreak of war led to the shelving of the problem. In the notorious Brest-Litovsk Treaty of 1918 Germany made another unsuccessful bid for a controlling voice in Spitsbergen affairs. Finally in 1919 the Supreme Council gave Norway sovereignty, under certain conditions regarding pre-existing claims, over Spitsbergen, Bear Island, North-East Land, Giles Land and adjacent islands. All interested powers and several to whom Spitsbergen was but a name, and wrongly spelt at that, agreed to this arrangement, and even Russia, which had once claimed the country, gave a tardy acquiescence. At the same time the decision was disappointing to some of the British capitalists who had sunk money in Spitsbergen. They had been ahead of Norwegians in prospecting the mineral content of the country, and if they had fallen behind in actual mining, the Great War alone was responsible. In those years British enterprise was naturally restricted while neutral countries, especially one like Norway lacking coal, were able and eager to develop their mines. Norway gained by the delay in settlement, for if a decision had been reached in 1914 some form or other of unsatisfactory international control would have been instituted.

By 1919 Norwegian control may have been inevitable, but it had become so largely through the indifference to private

enterprise and the ignorance concerning Spitsbergen displayed by the British Foreign Office. Norway is now facing the problem of a form of government that will interfere as little as possible with private enterprise and the authority of the various mining companies. Those who know Spitsbergen wonder if after all the old state of anarchy in a No-Man's Land was not best. It worked well and interfered little with mining interests.

At present all that is contemplated is the appointment of a Governor (*syssel-mann*) and a small staff who are to live at Green Harbour, the chief port of entry of Spitsbergen. It is calculated that the annual cost of upkeep will not exceed £10,000, a sum which will be derived solely by taxation of the mines and an export duty on coal. Drastic game laws are to be introduced in the hope of saving the wild life that has escaped the hunters. Reindeer, bear, foxes, walrus and eider duck are to be protected on all the islands of Svalbard and the number of hunters allowed is to be limited so as to prevent excessive inroads on the game. The north-western part of Spitsbergen, north of Ice Fjord and west of Dickson and Widje Bays, including Prince Charles Foreland, is to be reserved as a national park, and an area around Dickson, Klaas Billen and Sassen Bays is to be a botanical reserve from which certain rare species of plants may not be taken. Bear Island is to be another animal and plant reserve. In all cases the areas of the mining camps must necessarily be exempted.

Incidentally an issue of some interest might arise from Norway's decision that "Svalbard is a part of the kingdom of Norway." This was the formula adopted by the Odelsting in 1925 in preference to the wording "Svalbard is subject to the sovereignty of Norway." The rejected phrase is more in accord with the Treaty than the adopted one, since laws made for the kingdom of Norway do not necessarily apply to Spitsbergen. For instance, the Treaty lays down specific restrictions as regards taxation and the rights of non-Norwegian nationals. In these and other matters the Treaty overrides any laws made in Norway and applicable to the kingdom of Norway. Technically it will be necessary in future to exclude Svalbard from certain aspects of legislation passed in and for Norway.

The island of Jan Mayen in the Greenland Sea does not appear to have been annexed formally, but has been occupied since 1920 by a radio station of the Norwegian Geophysical Institute. It is also visited occasionally by Norwegian hunters. The Danes are said to own the buildings of the old Austrian meteorological station.

Claims to effective sovereignty in Antarctic regions are all of recent date with the exception of certain outlying islands. The long-drawn-out protest of Spain, and later the Argentine, against British possession of the Falkland Islands did not affect the ownership of other South Atlantic islands. Yet there were not lacking Argentinos who some fifteen years ago professed to see in the British claim to the South Shetlands and South Orkneys a usurpation of Argentine rights. No official claim to these islands had ever been made and the grounds of protest were weak. As regards the South Shetlands, an unconvincing and unofficial claim was based solely on the frequent visits of Buenos Aires sealers in the early part of last century. Other sealers had antedated them and were equally assiduous while the seals lasted, while in January, 1820, E. Bransfield, R.N., with full authority, that met with no protest, had hoisted the Union Jack on King George Island, three months after W. Smith had done the same.

The South Orkneys have been permanently inhabited since W. S. Bruce founded a meteorological observatory in Scotia Bay in 1903. In February, 1904, when the Argentine Republic took over this observatory, its official flag was hoisted and the islands were made a postal district under Rio Gallegos. With one mail a year, when the annual relief boat calls with a new staff, the postmaster's duties are a sinecure. In spite of the formality of hoisting the flag there was no formal Argentine annexation and none was implied. The islands remained a No-Man's Land till 1908, unless G. Powell's unofficial annexation for the British Crown in 1821 could be reckoned valid, which is very doubtful. South Georgia has been British since James Cook officially annexed it in 1775, but it had no permanent population until modern whaling started early in this century.

The Falkland Island Dependencies were formally claimed in 1908 when by Letters Patent the Governor of the Falk-

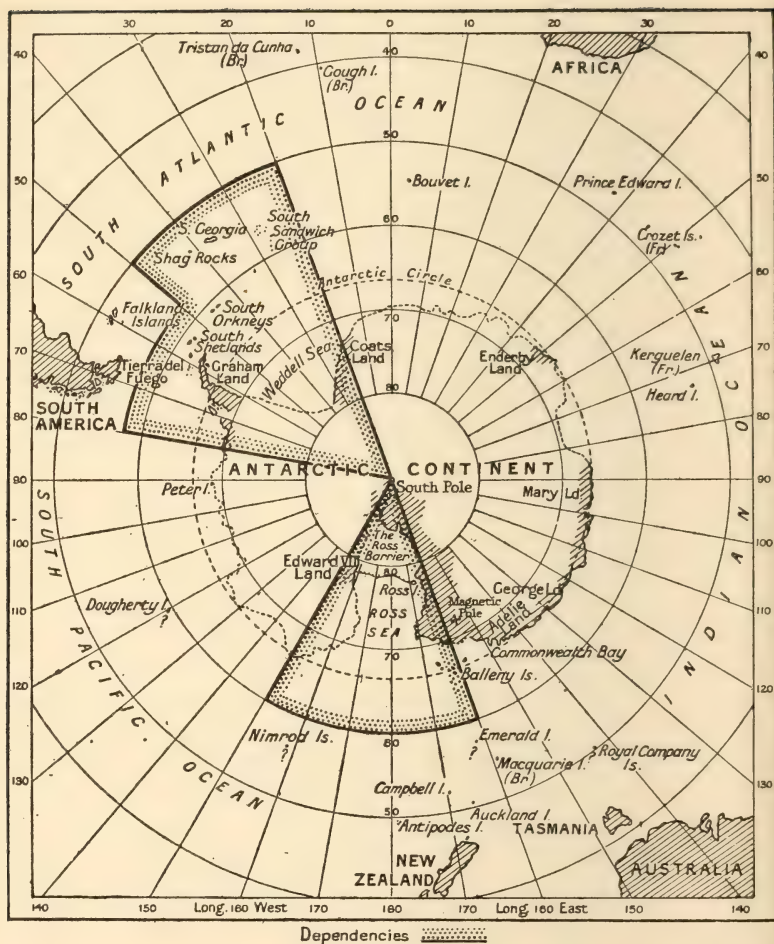


FIG. 15.—Map of Antarctic Regions showing British Dependencies

land Islands was appointed also Governor of South Georgia, the South Orkneys, the South Shetlands, the Sandwich Islands, and "the territory known as Graham's Land." These lands were stated to lie "to the south of the fiftieth parallel of south latitude and . . . between the twentieth and eightieth degrees of west longitude." The area of the dependencies was made more precise and comprehensive by further Letters Patent in 1917, the outcome, no doubt, of the spread of successful whaling which made it wise to leave no loophole of doubt for foreign claimants. It was then declared that the dependencies "shall be deemed to include and to have included all islands and territories whatsoever" between long.  $20^{\circ}$  and  $50^{\circ}$  W. south of lat.  $50^{\circ}$  S., and between  $50^{\circ}$  and  $80^{\circ}$  W. south of lat.  $58^{\circ}$  S. Thus British sovereignty was definitely asserted as far as the South Pole!

On the Pacific side of Antarctica lies the Ross Dependency of New Zealand, claimed in 1923 by an Order in Council under the British Settlement Act, 1887. J. C. Ross in 1841 officially hoisted the British flag on Possession Island and later British expeditions unofficially did so elsewhere around the Ross Sea, but such acts were not recalled and had doubtful validity. The Ross Dependency comprises all the islands and territories between long.  $160^{\circ}$  E. and  $150^{\circ}$  W., lying south of lat.  $60^{\circ}$  S., that is to say, the coasts of Victoria Land and Edward Land and the Ross Sea. It was of course the development of whaling, on the part of Norwegians, that led to this British claim. Magistrates temporarily visit South Georgia, the South Shetlands and other islands and accompany the floating factory which works year by year in the Ross Sea, representing British authority in these far-flung dependencies.

When Kerguelen-Tremarec discovered Kerguelen in 1772 he took possession for the King of France, declaring that he had discovered the long-lost southern continent. The Crozets, as well as Marion and Prince Edward Islands, are marked as British in some atlases, but they have been officially regarded as French since their discovery in 1772 and were definitely annexed in 1913. The claim has never been disputed since they are probably valueless except for a little sealing and as a depot for shipwrecked sailors. Heard and Macdonald Islands lie about 240 miles to the south-east of Kerguelen. Sealers

are the only visitors and the islands are apparently unclaimed by any State.

Since Kerguelen-Tremarec's discovery of Kerguelen, the island has always been regarded as French in negotiations for whaling and grazing leases, and at one time (1868) a possible coaling station. In 1893 a French vessel was sent to re-establish the claim of France, but there is no permanent population and at no time any representative of the French Government. France maintains, as on the Crozets, a depot of provisions and clothes for shipwrecked sailors and showed a sentimental interest in her isolated possession in 1915 by replacing with French titles certain German names due to the survey work of the Transit of Venus Expedition in 1874 and the German Antarctic Expedition in 1902. In November, 1924, a Presidential Decree announced that the Crozets, Amsterdam, St. Paul and Kerguelen, as well as Adelie Land, on the Antarctic continent were dependencies of the French possession of Madagascar. French jurisdiction includes control of the fishing and hunting, and a small stretch of the south coast and two small islands on the north, Howe and McMurdo, have been pronounced national parks in which no hunting is allowed.

Her claims to Adelie Land embraced the coastline of Antarctica between long.  $136^{\circ} 20' E.$  and  $142^{\circ} 20' E.$  (Greenwich) and lat.  $66^{\circ}$  to  $67^{\circ} S.$  This is henceforth an integral part of French colonial domains in which the fishing, hunting and mining rights are reserved for French subjects. On the grounds that this coast includes a considerable area explored by D. Mawson's Australasian Expedition, 1911-14, Australian opinion resented this action of France and made the counter-suggestion that the Commonwealth should lay claim to the whole of the Australian Quadrant or about one-fifth of the Antarctic regions. The matter does not seem to be one of vital importance since there is no probability of any visitors other than explorers to this coast, and they would probably dispense with the formality of asking any State's permission to be allowed to work in the Antarctic. The coast is useless for whalers.

South of Australia Macquarie Island, uninhabited except for an occasional sealer or exploring party, belongs to Tasmania. The Royal Company Island is a visionary depen-

dency of New Zealand since it does not exist. Campbell Island and the Auckland Islands belong to New Zealand. Emerald Island and the Nimrod Islands are myths. So is Dougherty Island farther east. An unclaimed island in the Southern Ocean is the tiny ice-covered and wholly useless Bouvet Island in lat.  $54^{\circ} 26' S.$ , long.  $3^{\circ} 24' E.$ , discovered by Lozier Bouvet in 1739 and hailed by him as an outstanding corner of the longed-for Terra Australis. Lindsay and Liverpool Islands are no doubt identical with Bouvet Island in spite of slight discrepancies of position. An unclaimed and possibly mythical island is Thompson Island, lying to the north-east of Bouvet Island. Liverpool and Thompson Islands were reported by the sealer Norris to have been discovered in 1825. Norris claimed them, without authority, for Britain.

## CHAPTER XVIII

### TRADE ROUTES

#### Northern Routes

**A**LTHOUGH the cherished dream of a transpolar sea-route to China and Japan has long ago vanished, several modern trade routes touch the Arctic regions and others are influenced by the drift of Arctic ice. The barrier of land that almost encircles the Arctic seas does much to confine the ice to northern latitudes and prevent its spread into temperate seas frequented by shipping. In three places this barrier is incomplete: Bering Strait, Baffin Bay with the straits leading to it, and the Greenland Sea. The sweep of the current across the polar basin from eastern Siberia would pour ice freely into the Greenland Sea and North Atlantic were it not for the action of the prevailing south-west winds and mild North Atlantic drift. These cause a gulf of warmth on the eastern side of the Greenland Sea and in the Barents Sea. Thus the ice is checked or destroyed and fails to reach the Atlantic sea-board of Europe. The east Greenland current on the western side of the sea carries cold water and ice southward, but little of either affects the Atlantic owing to the warm waters of the North Atlantic drift (see p. 80). On the other hand, the cold Labrador current from Davis Strait enters the Atlantic carrying much ice to the North Atlantic trade routes. The current spreads over the Great Banks of Newfoundland and at the Tail of the Bank meets the Gulf Stream which stems its flow and dissipates its waters in a number of branches. The Cold Wall is the line of demarcation between the two currents, but there is generally an interlacing movement of the two waters, the strongest branch determining the drift of the ice. Ice conditions vary seasonally. About January 1 the pack is off Belle Isle Strait and

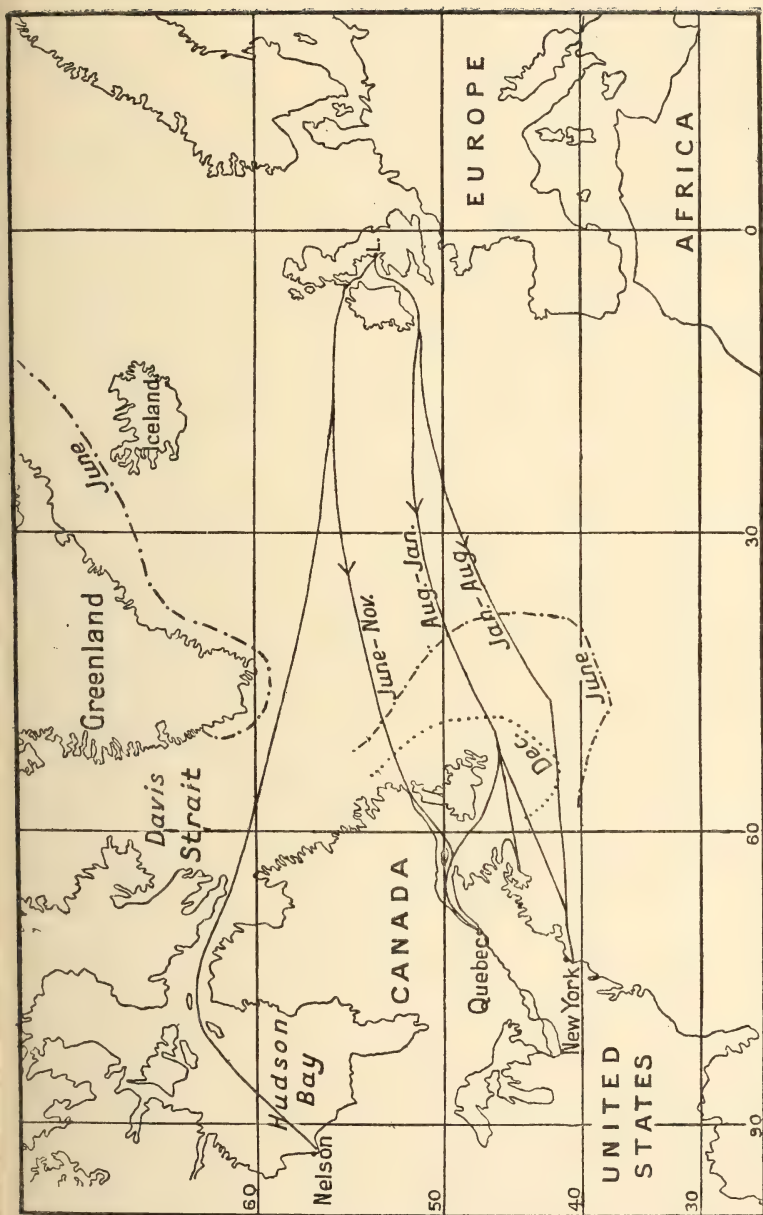


FIG. 16.—North Atlantic Trade Routes and average position of limits of ice in June and December

some two weeks later off St. John's. Early in February it reaches the Great Banks: in April it has its greatest extension and then begins rapidly to shrink. Later than the pack come the more dangerous icebergs. They first appear on the Atlantic routes in February and reach a maximum in April, May and June. The earlier ones have been imprisoned a winter in the pack and are often weather-worn, while the later ones are fresh from the Greenland glaciers, harder and generally more dangerous to shipping. When the current is at its strongest in summer the bergs move at speeds varying from half a knot to a knot and a half. In a normal year 300 to 350 icebergs of varying size pass the eastern coasts of Newfoundland.

Winter and spring are the dangerous seasons for shipping in an area which lies to the north of lat.  $38^{\circ}$  N. and to the west of long.  $38^{\circ}$  W. Outside this area ice is comparatively rare, but bergs which last longer than pack have been reported, in some cases on doubtful evidence, throughout the North Atlantic north of lat.  $30^{\circ}$  N.

In order to minimize the risk of collision with ice, the North Atlantic great circle trade routes are modified at different seasons of the year. From February 1 to August 31 vessels between Europe and United States and Nova Scotian ports make for long.  $47^{\circ}$  W. in lat.  $40^{\circ} 30'$  N. (eastbound) and  $41^{\circ} 30'$  N. (westbound) before changing their courses direct to their terminal ports. This keeps them well clear of the Great Banks. But the dates of changes of route vary from year to year. Even on this route vessels may encounter bergs. The greatest disaster in the history of sea-borne trade was the loss of the *Titanic* with 1,503 lives in April, 1912, after encounter with a berg in lat.  $41^{\circ} 46'$  N., long.  $50^{\circ} 14'$  W.

This disaster caused apprehension not previously felt, except by sailors, of the dangers of North Atlantic ice. The outcome was the provision of an Ice Patrol. At first this was conducted by vessels of the U.S. Navy, then by the former Antarctic ship *Scotia*, and now by the U.S. Coast Guard, the cost being met by the contributions of fourteen maritime nations. Two patrol vessels, which use Halifax, N.S., as a base, relieve one another on tours of two weeks' duration. The vessel keeps in touch with the limits of ice and any wandering bergs and broadcasts information twice

a day. The patrol, which starts in March, is not withdrawn until the routes are clear of ice in summer.

A further influence of ice on the North American trade is the complete closing of the St. Lawrence navigation from the end of November until the beginning of May. Of the two entrances to the Gulf of St. Lawrence, the most northerly, the strait of Belle Isle, begins to suffer from drift-ice towards the end of the year. In spring icebergs appear from the north and the navigation, which was closed in winter, does not re-open till late June. Even then a few bergs lurk around the straits. Cabot Strait, the southern opening of the Gulf of St. Lawrence, is closed from December to May. The ice congestion is worst in spring when the break-up of the frost causes a jam of ice between St. Paul Islands and Cape Ray. This "bridge," as it is called, may last several weeks and delay the opening of navigation. It is a complete barrier to all vessels. During the winter Canada thus loses the use of Montreal and Quebec and has to rely on Halifax and St. John for Atlantic shipping. On the Newfoundland coast the pack-ice may block the southern ports in February and March.

For about two centuries after the foundation of York Factory in 1682 and other forts in Hudson Bay, Hudson Strait was navigated every summer by trading vessels of the Hudson's Bay Company. More than 700 vessels used this route and two only are recorded as having been lost, which does not suggest exceptional dangers in navigation. From 1735 to 1889 there was only one year in which the Company's vessel, naturally a sailing ship, could not make the passage to Hudson Bay. The possibilities of this route have re-attracted attention in recent years with the growing settlement and production in the Canadian prairies. Grain and cattle from Manitoba, Saskatchewan and Alberta could be sent to Europe by a considerably shorter route than via Port Arthur and Montreal if vessels loaded on Hudson Bay. Not only would the total distance by Hudson Strait be shorter, but, a more important consideration, the land transport would be reduced by half or more. Thus a comparison of the distances from Saskatoon to Liverpool gives the following figures : Saskatoon-Winnipeg-Port Arthur-Sault St. Marie-Montreal-Liverpool, 1,489 miles by land and 3,359 miles by sea, lake

and canal, total, 5,848 miles ; Saskatoon-Le Pas-Port Nelson-Liverpool, 697 miles by land and 2,970 miles by water, total, 3,667 miles. In order to enable this route to be used a railway to Port Nelson on Hudson Bay was begun in 1911 and is now nearing completion. It is to end at an artificial harbour built around an artificial island founded on a sandbank about a mile from the shore in order to avoid the shallow water of the estuary of the Nelson River.

The usefulness of the route turns on the navigability of Hudson Strait, the 500 miles between Hudson Bay and the Atlantic. In depth of water there is no difficulty and the channel is nowhere less than 25 miles wide. There is little fog and there are no shoals : bergs from Davis Strait sometimes enter the channel but are not as numerous as off the Newfoundland Banks. The tide appears to set in along the north coast, carrying ice, and out along the south coast. Hudson Strait does not merit a bad reputation which it sometimes is given. Between early July and late October its navigation presents no real risk. The difficulty in beginning the season earlier is due to ice at the ends, from Fox Channel and in Davis Strait, rather than to much ice in Hudson Strait itself. In fact, it is probable that the waters of the strait could normally be navigated throughout the year, but winter darkness would add to the risk. Hudson Bay is not frozen over in winter, but ice forms round the coasts, and though the Nelson estuary is closed for six months the new port no doubt could be kept open by ice-breakers since the ice is seldom more than 10 inches thick.

Opinion in eastern Canada opposes and even ridicules this route, but is too largely moved by self-interest to be taken literally. When the new grain begins to move east to Atlantic seaports this route would be open. Certainly it would close before the Great Lakes and Montreal route, but the latter way closes before all, or even most of the grain has moved east, so that the delay associated with the Hudson Bay route is not a valid argument against its value.

In Greenland trade is restricted practically to the southwest coast which is accessible to ships between June and December, the only serious danger being in rounding Cape Farewell if the vessel is bound to or from Europe. From

September onwards is an open season on all west Greenland ports, but growing darkness restricts the period of navigation.

In Europe the only trade routes affected by polar ice are those to and from the coal-mines of Spitsbergen and those in the White Sea. The Spitsbergen shipping season lasts from May to the middle of October. Ice may occasionally cause a few days' obstruction in June or July, but on the other hand the west coast, to which all the shipping goes, is often open in April, although the fjords are still frozen. The warm Atlantic drift keeps the west coast mainly clear of drifting pack (pp. 80, 209).

Ice causes much more obstruction in the land-locked White Sea. It is all of local origin, practically no ice entering from the Arctic Ocean, and there are no icebergs. Arkhangel is open until the end of October or a little later, or with the help of ice-breakers to the end of the year. It is then closed until the end of May. At the beginning of the season delay is not infrequently caused, not by ice in Arkhangel harbour and vicinity but by the heavy ice congestion in the bottle-neck of the White Sea. Arkhangel cannot serve northern Russia as well as the ice-free port of Murmansk, the terminus of the Murman Railway.

In the northern Pacific ice has little effect on important trade routes. Bering Strait is narrow and the relatively weak and unimportant Kamchatka current, comparable in kind but not degree with the Labrador current, brings no ice to frequented waters. Moreover, the routes across the North Pacific do not go farther north than the Aleutian Islands. In the north-west the harbours, like in north-west Europe, are open all the year and ice is absent, but on the east coast of Siberia harbours from Vladivostok northwards are blocked by ice for varying periods from two to seven months and the land-locked Sea of Okhotsk, although itself open, has no approachable harbours during a long winter. Not till June does the pack as a rule recede into Bering Strait, and not till August is the strait itself sure to be clear. Alaskan harbours, except in the "pan-handle," thus have a long closed season ranging from about October to May.

There remains the navigation of the North-East passage, in whole or part, to be considered. As a through route it can

be dismissed as devious and unpractical, but the ends of it, particularly the western end, are not without value. This is often spoken of briefly as the Kara Sea route since that sea affords the most serious obstacle. The history of this route begun before English voyagers first tried for a North-East passage in the sixteenth century. Russian traders were then sailing between the White Sea and the mouths of the Ob and Yenisei, but they avoided rounding Yamal Peninsula by crossing it in river and portage via the Neite lakes, thus having to navigate only the easier, more open southern part of the Kara Sea. Then for many years this route was forbidden by the Russian Government in the hope of diverting trade by land routes through Tobolsk and so fostering the new trading station. When A. E. Nordenskiöld took the *Vega* in 1878 through the Kara Sea on his way to Japan he was accompanied by several trading vessels destined to ply on the Siberian rivers. The same year and in several subsequent years, Captain J. Wiggins brought cargoes of Siberian produce by this route to Europe. It was used for materials during the construction of the Siberian Railway and again for stores during the Russo-Japanese War to relieve the congestion on the railway. From 1912 onwards few years have passed without several steamers loading at the mouth of the Ob and Yenisei cargoes for Europe—timber, hides, flax and butter.

The difficulty lies chiefly in the pack-ice in the Kara Sea. The eastern Barents Sea is seldom blocked between late July and late October and in any case the pack in these waters is fairly loose and not likely to crush a vessel. The first problem relating to the Kara Sea is the selection of the best entrance. Of the three entrances from the west, Matochkin Shar, Kara Strait and Yugor Strait, the first is of little value and the last is generally preferred. Once in the Kara Sea a vessel has to encounter the ice that formed in that sea the previous or earlier winters. There is little ice from the polar ocean and there are no bergs. Tides and especially winds affect the movements of this ice. South-west winds force the pack to the east and may leave a passage on the north-west. This is often considered the best part to make for if a crossing is attempted early in the season, but since north-east winds are common in summer it is often best at that season to make

eastward and get between the pack and Yamal and steam north in the land water. August and September are the best months for navigating the Kara Sea: in September it has even been found free from ice.

In 1914 the Russian Government prepared to erect several radio stations around the Kara Sea in order to warn vessels of ice conditions. They were to be at Mare-Sale on Yamal, at the east end of Yugor Strait, on the north coast of Vaigach Island, on Byeli or White Island, and one on Novaya Zemlya.

East of Yamal there is less difficulty at least during August and September, for, even if pack-ice occurs, there is frequently a channel of open water along the land and when once the big rivers have discharged their winter ice, by late June, the warmer fresh water rots the ice near the river mouths. But the islands of the Nordenskiöld Archipelago to the west of Cape Chelyuskin may cause serious ice congestion. Vessels attempting to go farther east have at times found the Nordenskiöld Sea, east of the Taimir Peninsula, an ice-congested region. No doubt Nicholas Land helps to hold the pack moving westward. But trade to and from the Lena and Kolima river mouths is small in amount and goes via Bering Strait. From late July to September this route is generally open, for the big river discharges help; but data are somewhat scanty. Some successful trading has been done between Vladivostok and the mouth of the Kolima River. The ice lies to the north of the open water and Wrangel Island is more often within than outside the ice limits.

The great development in the use of aircraft since the war has drawn attention to the possibilities of air routes across Arctic regions for communication between Europe, America and Asia. New methods of transport have revived the old desire for North-West and North-East passages. At present the shortest route between Britain and Japan is by the Siberian Railway, but 2,000 miles could be saved by an air route by Iceland, Spitsbergen, Franz Josef Land, Cape Chelyuskin and thence across Siberia. This would be longer than the direct route via Tromsø and Novaya Zemlya, but it might have an advantage, by being more northerly, in affording more daylight in summer. A route across Greenland is the shortest way, in respect of mileage, to western Canada, and a route

from Canada across the Arctic Ocean via Wrangel Island may become the way to Japan. Stations for fuel and repairs would be necessary on these routes, and hence a new value for various Arctic islands if they are easily enough accessible by store ships and afford good grounds for landing. It was for this reason that Stefansson was anxious to make Wrangel Island British territory. One who knows nothing of flying can offer no useful opinion on the possibility of these projects, but Amundsen and Byrd have shown that airship and aeroplane are serviceable means of locomotion in Arctic regions (p. 19).

### Southern Routes

No land barriers prevent Antarctic ice spreading northward into the Southern Ocean, but winds and currents confine it mainly to the south of lat.  $55^{\circ}$  S. There are, however, seasonal and perhaps cyclic fluctuations in the amount and extent of the ice. Pack-ice drifts farthest north in spring and early summer when higher air temperatures, by preventing the freezing of drifting ice, allow it to spread to warmer seas. Bergs, with their greater surface exposed to winds and currents and their slower melting, float farther northward than pack-ice. They may drift to  $35^{\circ}$  S. in the Falkland current which sets north to the south-east of South America, and they are common in the South Pacific, especially between long.  $105^{\circ}$  and  $125^{\circ}$  W., beyond the limit of the pack, and in the Indian Ocean about the latitude of the Crozets and Kerguelen and to the south-west of Australia. Many huge bergs have from time to time been sighted by merchant ships on customary trade routes. The length of several of these bergs has doubtless been exaggerated since the heights in most cases, recorded in the Meteorological Charts, exceed the height of bergs that have been carefully measured in Antarctic seas.

Great as is the volume of Antarctic ice of both sea and land origin, it affects trade routes but little. As a rule it is too far south to have much concern for merchant sailors, except in the Cape Horn seas, where more than one vessel "posted as missing" must have met her fate by collision with a wandering berg or the pack sweeping north. The risk of ice in Drake Strait militates against the advisability of sailing ships standing well to the south, in order to pick up the polar

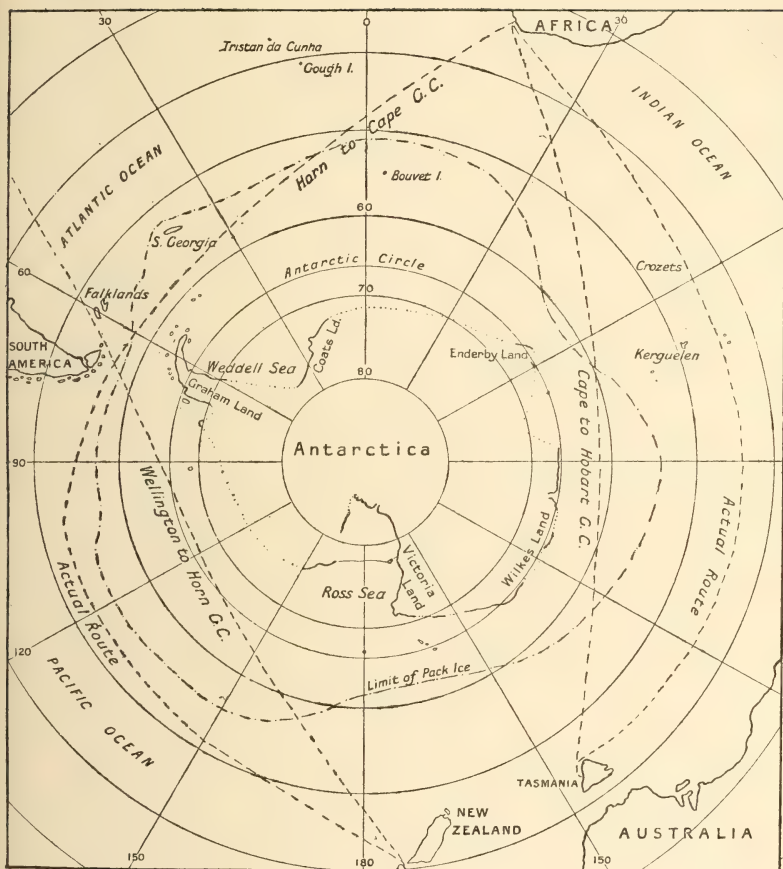


FIG. 17.—Routes in the Southern Ocean  
G.C.—Great Circle Route

easterlies, in "rounding the Horn" from Atlantic to Pacific. On the other hand, it is in midsummer when there is practically no night in these high latitudes that this course is most advantageous. During winter when the Antarctic anticyclone is most extensive, the easterly winds are often found much farther north.<sup>1</sup> June and July are considered to be the best months for the westbound passage round the Horn. Steamers of course gain nothing and lose time by taking a southerly route in Drake Strait.

Tonnage using the Cape Horn route and the alternative by the Straits of Magellan promises to fall to a very low figure consequent on the opening of the Panama Canal, which offers a more attractive and shorter route for practically all steamers passing between the Atlantic and Pacific Oceans.

For the same reason shipping across the southern Pacific and in the south-western part of the South Atlantic has fallen off considerably of late years. As the deep-water sailing ship disappears from the seas these routes will be less and less frequented. On the other hand, the route across the Southern Ocean from South Africa to Australia will retain a certain value as an alternative to the Suez route and one which has advantages as regards distance compared with the Panama route.

The presence of Antarctic ice prevents the great circle routes being used either from New Zealand to Cape Horn or from South Africa to Australia or New Zealand. Between New Zealand (Wellington) and Cape Horn the great circle route touches lat.  $66^{\circ}$  S. and is about 4,170 nautical miles in length. Vessels cannot safely dip south of lat.  $53^{\circ}$  till Cape Horn forces them to do so, and thus have to add about 450 miles to the run.

On the route from "the Cape" to Australia and New Zealand the flattening of the great circle track is more marked, for a plentiful supply extends the drift of floating ice to a lower latitude than on the Pacific side. If, however, all risk of bergs were to be avoided, a course keeping north of lat.  $40^{\circ}$  S. without any reference to circle sailing would have to

<sup>1</sup> Easterly winds in Drake Strait may also be the easterly components in the air currents on the south of a travelling cyclone. In this case they are liable to shift to another quarter.

be followed. The great circle route from the Cape to Hobart (Tasmania) is 5,350 miles and dips to lat.  $62^{\circ}$  S., while the course generally followed keeps north of lat.  $44^{\circ}$  S. and is 5,840 miles.

The route across the South Atlantic in high latitudes is seldom followed by vessels, because it does not lie on the way between the industrialized trading countries of the northern hemisphere and the new countries of the south. Only whalers, specially built for the purpose, enter these deserted waters. Thus several islands and island groups in the South Atlantic were unexplored until quite recent times and even now are poorly known, e.g. the South Sandwich group, the South Orkney group, Bouvet Island, and even Gough Island. The shortest route between Cape Horn and Capetown would pass through the South Sandwich group, but no vessel would follow that course.

Even these deviations from the shortest courses do not free vessels from the danger of colliding with ice in the Southern Ocean. Certain areas which have been mentioned are notorious for the presence of icebergs, especially in the height of summer when, fortunately for the navigator, there is little darkness.

One other aspect of trade routes deserves mention, that is the tourist traffic and passenger routes to polar regions. Generally speaking, the tourist or passenger with no particular business in view is barred by lack of communication from reaching polar regions except in a specially chartered vessel or private yacht. And on account of stormy seas and heavy pack no yacht is ever likely to be risked in Antarctic waters. Many, however, have gone to the Arctic, especially Spitsbergen, and Novaya Zemlya, where the "gulf of warmth" minimizes the danger from ice. Spitsbergen offers an ideal summer cruising ground for the yachtsman to whom the sea in all its moods, and summer skies and quiet beauty are sufficient attraction. The Marquess of Dufferin's *Letters from High Latitudes* is a delightful account of a voyage to Spitsbergen in 1856. There are no hardships and little discomfort about such a cruise, but the yachtsman would be well advised to overcome any temptation to visit the mist-ridden Jan Mayen and Bear Island. For many years, except during the war,

several large steamers, Norwegian, German, French and less often British, made tourist cruises to Spitsbergen in July and August, visiting the chief fjords and bays on the west coast and sometimes giving passengers a view of the polar pack. For two years, 1896 and 1897, there was even a small tourist hotel at the mouth of Advent Bay, served by a weekly steamer from Norway. With shooting, boating, mountain climbing, tennis and dancing, the hotel should have prospered, but the terror of the Arctic was still strong in those days, and the scheme failed. The hotel was moved to Longyear City, where it is now the store and shop.

The only parts of the Arctic to which there are regular mail services, of course only in summer, are Greenland, Spitsbergen, and the Mackenzie delta. All Greenland mails go via Copenhagen and all Spitsbergen mails via Norway, often Harstad, but sometimes Oslo, Bergen or another port. During summer there are regular steamer services on the Mackenzie and Slave rivers connecting in the south with the railhead at Waterways near McMurray on the Athabaska River and terminating in the delta at the small trading station and police post of Aklavik. From December to April this means of communication is replaced by dog sledges and two regular winter mails reach the coast. In the months of April, May, October and November, when the river ice is breaking or forming, there is no communication. The coast of Alaska has regular mail services, and in summer there is irregular connection eastward from Herschel Island to Coronation Gulf.

In the Antarctic there are irregular mail services by whaling vessels to South Georgia, generally via Monte Video and to the South Shetlands via the Falkland Islands.

## CHAPTER XIX

### COLONIZATION

#### I. Greenland and Novaya Zemlya

**T**O Eric the Red belongs the honour of first attempting the colonization of Arctic Regions. It was some eighty years after Gunnbjörn's discovery, about 900, of the islands and skerries which were afterwards called Gunnbjörn skerries, that Eric the Red, outlawed from Iceland, set out to seek this land in the west. He spent three winters in different parts of the south-west coast before he returned to fetch the first party of colonists, about 985. Immigration then went on rapidly in two districts: the eastern settlement Oesterbygd extended from Cape Farewell to about  $61^{\circ}$  N. and corresponds to the Julianehaab district to-day: the western settlement, Vesterbygd, corresponding roughly with the Godthaab district, lay between lat.  $63^{\circ}$  and  $66^{\circ} 30'$  N. There were no permanent settlements on the east coast or in the far north, which suggests that the conditions of drifting ice were the same as to-day. The name Oesterbygd caused confusion in the search for the remains of these settlements many centuries later by suggesting that it was on the east coast. Hans Egede in 1723, W. A. Graah in 1828 and even later explorers made this mistake, till eventually in 1885 G. F. Holm, in finding the real site of Oesterbygd, revealed the truth. The two sites of the colonies were well chosen. In each the ice-free margin of Greenland widens to a hundred miles or more: the eastern colony lay in a sort of gulf of open country in the ice-cap. The Norsemen settled not on the coast but well up the fjords where they had protection from coastal gales and exceptional warmth in summer with a fairly rich vegetation, at least the richest in Greenland, affording pasturage, firewood and shelter. Lastly the alluvial soil at the head of fjords was more fertile than any other. In this wise choice of



FIG. 18.—Greenland—Colonization

The dotted line shows the limits of the ice sheet. Osterbygden, Vesterbygden, Old Norse colonies. Initial letters indicate chief modern settlements. E. Etah. T. Thule. U. Upernivik. Gn. Godhavn. J. Jakobshavn. Eg. Egedesminde. H. Holsteinborg. G. Godthaab. I. Ivigtut. J. Julianehaab. A. Angmagssalik. M. Mygbukten, Norwegian Meteorological Station (temporary). J.M. Jan Mayen, Norwegian Meteorological Station. Reykjavik, Iceland.

sites for the settlers from Iceland, Eric the Red showed great enlightenment and foresight. He must rank among the great colonizers of all time even if his work eventually perished, through the operation of factors which he could not foresee.

F. Nansen believes that the total Norse population of Greenland was never more than 2,000, while G. F. Holm puts it at 3,000. The people lived not in villages but in scattered farms, some of them of great size. At the height of its prosperity early in the thirteenth century Oesterbygd had 190 farms and Vesterbygd had 90. The dwellings were built of stones and peat and around them were the walled fields for cattle and goats and, to a less important extent, sheep and horses with stables, also built of stones. Cereals were of little importance: the *King's Mirror* says the colonists scarcely knew what bread was, but they had milk, butter and cheese. They also hunted polar bears, reindeer, foxes and seals. Probably they fished cod, but fish bones are scarce among the ruins, perhaps because they have decayed or possibly because the bones, thrown with the offal, were fed to cattle or eaten by bears and foxes. By trade with Norway the colonists got corn, wood and iron.

Christianity was introduced about the year 1000 and Greenland was a bishopric from 1126 to 1377. Thereafter until 1550 bishops were appointed but never went to Greenland. There were many churches, including a cathedral church at Gardar on Igaliko fjord. It was 85 feet long and 36 feet wide. The colonists paid their tithes in skins and ivory.

These adventurous Norsemen were not content to remain in ignorance of the lands around them. At one time or another they made voyages as far north as about lat.  $72^{\circ}$  N. and they seemed to have known something of the east coast as far as Scoresby Sound. Across Davis Strait they knew Baffin Island and Labrador and perhaps Newfoundland. Certainly they discovered America about five centuries before Columbus. A great deal of speculation has centred round the voyages to Vinland recounted in the sagas. No definite conclusion has been reached as to the truth of this story, but Nansen, in an exhaustive discussion of all the evidence, is forced to believe that the tale was a myth, and merely the Norse version of the happy lands away across the Atlantic which other peoples in

Europe knew as the Fortunate Isles, or the Isles of the Blest.<sup>1</sup>

The Greenland colonies surrendered their independence in 1261 and accepted the sovereignty of Norway. Trade became a royal monopoly restricted to one ship a year, called *Knarren*. Soon after this Norway fell on evil days: the dominance of the Hanseatic League meant the eclipse of Norway's shipping: the black death marked nine years without a ship sailing for Greenland, and finally Bergen, the headquarters of the Greenland trade, was burnt in 1393. The last vessel from Norway to Greenland sailed in 1410: after that a long silence fell over the Arctic colony.

Before the end of the fourteenth century the Eskimo had become numerous in the colonies, probably due to a steady southward migration (p. 151). The Norsemen, forced by languishing trade with Norway to fall back more and more on the resources of the country, lost their supplies of iron and timber. Weapons and ships became less effective: the people on a sparser diet, when flour ceased and stocks could not be renewed, no doubt lost in physique and vigour. Contests occurred with the Eskimo, in some of which the Eskimo were victorious. There is a tale that in 1350 the whole western settlement was destroyed by the Eskimo, but that probably was an exaggerated statement, built on a slender foundation. Nansen does not believe that any war of extermination took place or that the disappearance of the Norse settlers can be attributed to the Eskimo. He thinks rather that, deserted by Norway and left to their own resources, they fell away from their civilization and adopted the mode of life of the Eskimo, that intermarriage resulted and gradually the Norsemen through want of fresh blood were absorbed in the Eskimo. At any rate they disappeared, and when communications were reopened with Greenland by Denmark late in the sixteenth century no sign of the early settlers was found.

Recent researches of P. Nörlund and others in Greenland

<sup>1</sup> Other authorities find more substance in the story and see Vinland in Hudson Bay, Labrador, the St. Lawrence, Newfoundland, Nova Scotia, Cape Cod, or Rhode Island. A useful discussion of recent writings on the subject is by W. H. Babcock in the *Geographical Review*, April, 1921.

have necessitated a revision of these ideas and shown that even if the race deteriorated physically they maintained their culture to the end, which suggests that there was little intermarriage with and certainly no merging in the Eskimo. The evidence was found in the careful examination of some two hundred graves in which clothes and ornaments were found. The style and texture of the clothes indicate that Greenland must have had relations, by privately owned vessels, probably in the Icelandic fish trade, long after *Knarren* had ceased to sail, perhaps as late as the end of the fifteenth century. Not only do the clothes and material indicate fashions of that century in Europe, but they show practically no trace of Eskimo influence. On the other hand, the examination of the skeletons disinterred furnishes the explanation of the extinction of the race. Among the most recent remains at Herjolfsnes, one of the important settlements of Oesterbygd, it was found that the stature of the men did not exceed 5 feet 4 inches, and that of the women was only 4 feet 6 inches to 4 feet 10 inches. Furthermore, all the remains showed malformation, and signs of rickets. Many of the women had obviously been little fitted for child-bearing and there was an undue proportion of young people and infants. These skeletons, F. C. Hansen believes, show every indication of a perishing race, succumbing to lack of nutriment and possibly degenerate by excessive intermarriage. The possibility of a change in climate being responsible is considered on page 47.

It must, however, be remembered that Herjolfsnes was a somewhat isolated settlement out of close touch with the larger settlements farther north especially when lack of timber supplies had no doubt caused a decline in boat building. Larger settlements may have endured longer. Their fate may even have been due to swamping of the Norse culture among the growing number of Eskimo, although there does not appear to be any Norse strain in the modern Eskimo tribes.

Greenland is now an Eskimo reserve. There are no Danish settlers except a handful of officials and the cryolite miners, a total of about 400 Danes scattered generally in groups of not more than four or five in the various settlements. The Moravian missions which began their activity in 1733 were withdrawn in 1900 and since then the Lutheran Church of

Denmark, supported by a State grant, has provided the only churches and schools in the country. Nearly all the natives can read and write, a few know Danish and some rise to be teachers and pastors. There is a scientific station on Disko Island, which is a centre of active research by Danish workers and has a large Arctic library.

The Greenland Eskimo of to-day live by hunting and the sale of their produce to Denmark. Seal-skins, blubber, sharks' livers, fox-skins, bear-skins and eiderdown are the chief commodities of trade. There are few reindeer-skins and a little narwhal ivory. The hunting produce exported in 1914 was valued at £53,000 (see p. 172).

Denmark has tried to form Eskimo colonies on the deserted east coast of Greenland. The Scoresby Sound district has been selected as being rich in game, and on the site of old native huts new houses were erected and settlers introduced in 1924 and 1925 at Amdrups Harbour, Cape Stewart, Cape Hope and Cape Tobin. This no doubt is a tangible assertion of Denmark's sovereignty to the east coast of Greenland (p. 171).

The rock structure of the country does not favour mineral occurrence. Greenland is a plateau of ancient crystalline rocks with areas of folded palæozoic strata in the north and north-west. But the greater part of Greenland (some 94 per cent) is covered by the ice-cap; only the borders of the island are bare. As long ago as 1850 a concession was granted to a company for exploring the minerals and working mines. Nothing came of this venture except that attention was drawn to the deposits of cryolite, a rare fluoride of sodium and aluminium, which is found in very few localities outside Greenland. It is used with bauxite in the manufacture of aluminium and also in the making of certain kinds of opalescent glass. For many years the Eskimo knew the "ice stone," which by reason of its weight was useful to them in anchoring fishing nets and pegging down tents, but the deposits at Ivigtut in Arsukfjord near the south of Greenland were not investigated till the early years of last century and not worked till 1857. Since then there has been a considerable output most of which now goes to Copenhagen and a little to Philadelphia by the only privately owned vessels that ever call at Greenland and the only regular communications with the New World. The cryolite mine is an open pit

200 feet deep, from the side of which the mineral is blasted. It falls to the bottom, is shovelled into tubs and hauled to the surface and loaded into vessels which lie alongside a small jetty in the sheltered waters of the fjord. The output in 1924 was 23,800 tons. Royalties on the output are paid to the Danish Government, for cryolite is the only commodity which is outside the trade monopoly of the Danish State. Only Danish labour is used, about 15 engineers and 130 miners and workmen, who are housed in the settlement of Ivigtut. The work is hard and even dangerous when it entails swinging on ropes over the face of the pit to drill the blast holes and insert the charges. But there is no lack of applicants when men are enrolled in Copenhagen. Eskimo have been found to be unsatisfactory for the work, and in any case their employment is now forbidden by the Danish Government. Mining goes on throughout the year, but export is confined to the summer months. The cryolite deposit is believed to be limited in amount, and another fifteen years is spoken of as the life of the mine at its present rate of output.

There are other mines in Greenland of less importance. Graphite is mined at Amitsok and near Upernivik. A little is sent to Denmark. Steatite or soapstone was used by the early Norse settlers and the Eskimo for lamps and pots, but its value has now gone in face of competition with European metal ware.

Coal is of more importance but only for local use and not on a large scale. The chief coal mine, owned by the State, is on the north of Nugsuak peninsula at Kaerssuarsuk. It is bituminous coal of Tertiary age and is worked by Eskimo labour in short adits.

There are also thin seams exposed in Disko Island and other parts of the west coast, which is available to anyone who chooses to work it, but most is of a poor quality.

Metallic ores are numerous in small quantities. Copper, lead, zinc and silver have all been reported, mainly at Ivigtut, but desultory attempts at working them have failed. The only important metal is meteoric iron, which used to be highly valued by the natives. It is found in various places, particularly near Cape York, in masses which weigh up to several tons. Before trading with the white man began this meteoric

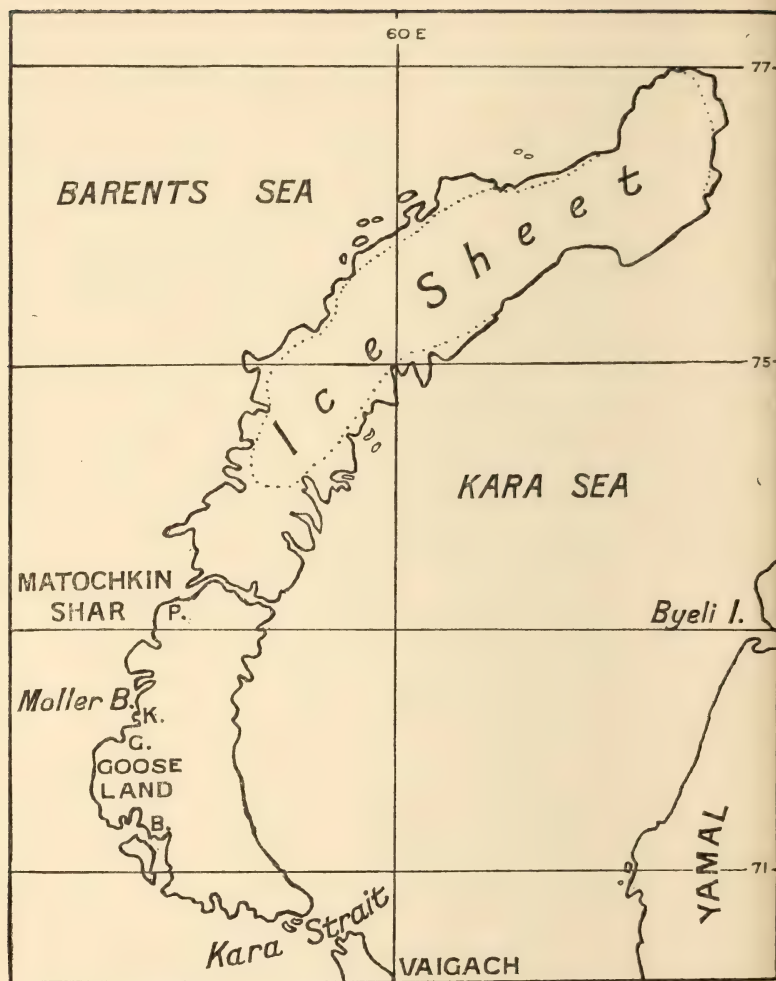


FIG. 19.—Sketch map of Novaya Zemlya showing Samoyede settlements and limits of ice-sheets

*P.* Pomorskaya Bay. *K.* Karmakul. *G.* Gusinoe. *B.* Byelushya Bay.

iron was invaluable to the natives for knife and spear blades, but now is little used. Until a century ago the Polar, or Cape York Eskimo, had no other source of metal than this nickel-iron of meteoric origin. Peary in 1896-7 brought back three of these meteorites from Cape York, which are now in the American Museum of Natural History. The largest weighs 90 tons. A smaller one was taken to Copenhagen a few years ago.

The colonization of empty Arctic islands by far northern races has from time to time been suggested and on one or two occasions tried. Early in the seventeenth century the Muscovy Company obtained a licence from the Tsar of Russia for the purpose of making a Lapp settlement in Spitsbergen, mainly in order to protect the whaling gear that was left ashore from year to year. But the proposal came to nothing. Over a century later when Russian trappers frequented Spitsbergen and spoke in glowing terms of the amount of game, some Samoyede families begged in vain for transport for themselves, their families and reindeer.

In Novaya Zemlya, however, the experiment of Samoyede settlements has been tried with some success. The conditions on the whole are favourable. Novaya Zemlya is an extension of the Ural folded mountains with a central zone of Archæan and Palæozoic rocks rising in places to over 3,500 feet and flanked on both sides by a strandflat of Palæozoic rocks at an elevation of from 60 to 500 feet. There is a considerable area of relatively flat and low-lying land much cut by ice and river action and well indented by inlets of the sea, many of which are good harbours. Matochkin Shar or Strait is a narrow winding channel easily navigable by small vessels between July and October. A relatively small part of the interior has an ice-covering (p. 110). The islands had no inhabitants until 1877, when, alarmed at the growing numbers of Norwegian hunters who visited them, the Russian Government started a scheme of Samoyede colonization. Five Samoyede families from the Mezen district were settled at Karmakul Bay to the north of Goose Land to fish and hunt. A steamer visited them annually. Other families were added later and most moved to Pomorskaya Bay in Matochkin Shar. In 1897 colonies were also formed at Byelushya Bay on the south of Goose Land

and at Guisnoe on Moller Bay. The settlers have no tame reindeer but hunt bears and fish salmon. They live in wooden houses and there is a church and used to be a Russian priest at Priyut, the settlement at Karmakul, for the benefit of the Russian traders, and the Samoyedes who profess a nominal Christianity.

In the view of the mineral wealth of the Urals the poor results of prospecting in Novaya Zemlya are surprising. A little poor coal occurs and some copper ore of value is said to occur.

Vaigach and Kolguev are small islands visited by Samoyedes, but they are detached pieces of the mainland of Europe rather than Arctic islands. The archipelago of Franz Josef Land is both too inaccessible and too ice-covered ever to have any economic interests except to a few enterprising hunters. The islands north of Asia have never been colonized, the native hunters who visit some of them, as the New Siberian Islands, being only temporary visitors (p. 137). An attempt to found a settlement on Wrangel Island, which does not promise to be lasting, is referred to in an earlier chapter (XVII).

## CHAPTER XX

### COLONIZATION

#### II. Spitsbergen

**T**HE Dutch, English and other whalers who frequented Spitsbergen in the seventeenth century were not permanent settlers, but only summer visitors. In fact they dreaded the possibility of having to winter, believing that no man could survive the cold and other terrors of the Arctic night. Efforts to obtain winter settlers, to take charge of the whaling establishments, by offers of high pay were as unavailing as a desperate attempt to offer criminals a reprieve if they would winter in Spitsbergen. Report has it that when they saw the country they had undertaken to live in they preferred to return to London and imprisonment, which, however, was remitted. Gradually these fears were overcome. Men were left by accident and survived the winter, though others perished from scurvy, but the abandonment of whaling along the coasts put an end to any attempts at settlement. The deserted summer stations can still be traced by the brick foundations of the blubber-boiling coppers, scraps of old dwellings and the graves of many cemeteries. At Heemskerke Ness on Prince Charles Foreland, on the Norway Islands, on Amsterdam Island, on Danes Island, at Treurenberg Bay and elsewhere are many graves dating from the great whaling days. The largest settlement, solely a summer town for boiling blubber, was Smeerenburg on Amsterdam Island. Between 1633 and 1643 it reached the height of its prosperity and had about 1,200 inhabitants besides the population of several hundred whalers lying in the bay. The huts, or tents, as they were called, ran to fairly considerable size: the largest were 80 feet long and 50 feet wide and had two stories. There were a church and shops with tobacco and brandy for sale, and bake-houses supplied hot rolls every morning. There were even

ladies too, if all reports were true. And the Dutch built a fort as protection against Danish whalers.

A more lasting attempt at colonization, but without State initiative, was made by Russian trappers. It is uncertain when they started. Possibly before the Dutch re-discovery in 1596 Russians visited Grumant, as they called Spitsbergen. But the evidence is not conclusive and certainly the whalers made no mention of Russian hunters. Early in the eighteenth century they came in large numbers for white whales, walrus, seals, bears and foxes. They were men from Arctic Russia, inured to cold and winter gloom. The enterprising monks of Solovetski and the Russian White Sea Company financed many voyages. Some hunters went only for the summer for white whales and walrus, but most went for the winter to trap furbearing animals whose summer coats are valueless. From their earliest settlement on Edge Island they gradually spread west and north as game became scarcer and their numbers increased. There are few stretches of coast except on the ice-bound east where Russian huts have not been recorded or ruins and graves are not to be found to-day. Like all hunters they had to scatter widely, and probably in no year were there more than 500 in Spitsbergen. They brought logs with which to build substantial huts, many of which would be standing yet if the timber had not been used for other purposes by later visitors. Generally wooden crosses were erected near the larger huts. Some huts had glass windows, out-houses for stores and even bath-houses. Much food was brought from Russia, meal, pease, eggs, salt beef, dried cod and halibut, honey, oil and whey. Train-oil from seals was a favourite delicacy. No doubt they fed well but they were extremely dirty, and in spite of preventive measures, like reindeer and bear-flesh and scurvy grass for food, they suffered much from scurvy and there was a heavy mortality. They played ball games at times and clearly valued exercise for its own sake. Hard though the life was, it proved attractive, and many trappers stayed several years at a stretch. One is said to have lived thirty-six years in Bell Sound and another spent fifteen consecutive years and a total of thirty-nine years in his hut in Green Harbour, where he lies buried at Cape Staratchin, named in his memory.

In the nineteenth century the numbers of Russian trappers began to fall off, and Norwegians took their place. By 1827 the Spitsbergen hunting was the main support of Hammerfest. Later on Tromsø became its rival. But the hunting was mainly in the summer for white whales, walrus and seals. The winter game had been so reduced by the Russians that it was many years before the Norwegians took to trapping on a large scale. Even then it was not so much the recovery of the game but the soaring prices of furs that made the occupation profitable. Early this century there were probably 200 Norwegian hunters scattered round the coasts of Spitsbergen every winter taking reindeer, foxes and polar bears, and, in summer, eiderdown and white whales. They built rude shanties, generally of drift-wood, where they lived in twos and threes. As game became scarce they spread even to the east coast and finally took to the dastardly practice of using poisoned bait. That spelt ruin and nearly ended the Spitsbergen hunting for all time.

Norwegian Arctic hunting was never confined to Spitsbergen. The hunters visited Jan Mayen, East Greenland, Novaya Zemlya and even Franz Josef Land, but Spitsbergen was their mainstay because it was so easily accessible. In 1910 when the Arctic hunting was at its high-water mark it brought a total profit of some £50,000. In 1906 the thirty-one sloops from Tromsø took a total of 296 bears, 135 walrus, 141 foxes, 2,888 reindeer, about 6,000 seals, 1 narwhal and about 1,000 lbs. of eiderdown. The new game regulations in Spitsbergen have now practically put an end to trapping.

From time to time fox farms have been proposed for Spitsbergen, and there is nothing in the climate to render them unprofitable. Fences and feeding would be the chief expense, and a watchful eye would need to be kept on polar bears in winter.

While fur-hunting was still at its height, a new interest drew men to Spitsbergen. Scientific exploration in the nineteenth century revealed a number of valuable minerals including large coal-bearing areas, though coal had actually been known to the early whalers. Spitsbergen has a great variety of geological formations from the Palæozoic rocks, known as the Hecla Hook series of Ordovician and Silurian Ages, which form

the contorted and overthrust beds of the old Caledonian folds on the west, to the Secondary and Tertiary beds which loom large in the centre and east. Below these newer rocks there lies a basal platform of pre-Devonian if not pre-Cambrian crystalline rocks. The newer rocks of the centre and east lie unconformably on the older rocks and form a plateau which appears to be built of almost horizontal strata, but in reality shows very gentle folding. Glacial and post-glacial deposits in many parts mask the solid rock and as a rule scree of recent formation form fans down the hillsides.

Apart from the Caledonian movement which formed the rugged scenery of the west there was clearly a tangential movement in Tertiary times which resulted in the gentle anticlines of the table mountains of central Spitsbergen, the highly tilted Jurassic and Tertiary beds on the east, the overthrust of the Hecla Hook beds eastwards over many of the younger rocks, and the occurrence of great faults which have led in several cases to the penetration of arms of the sea far into the interior.

The coal-bearing area is mainly in the central part of Spitsbergen, around the great Ice Fjord and to a less extent Lowe Sound. It also reaches to the east coast, is found in a few isolated areas on the west coast and occurs in Bear Island. The lower Carboniferous beds contain numerous seams partly above and partly below sea-level, with a total coal reserve estimated at 1,500 million tons. They are mainly good coking coals. Cretaceous coal is less extensive and is of a poor quality with a high percentage of ash, but there are 1,500 million tons of this coal. Lastly there is the Tertiary coal, which is the most accessible and of the highest quality, most of it is above sea-level. The total reserves are estimated at 8,000 million tons. It has proved to be an excellent steam coal. Bear Island has some poor Carboniferous coal and a little Devonian coking coal.

Early in the nineteenth century a few small cargoes of Spitsbergen coal were brought to the iron mines of Kjøfjord in Finmark, but this was only outcrop coal. Yachts occasionally made use of the coal seams, but it was not until 1900 that any claims to coal-bearing land were made. Thereafter for some twenty years numerous claimants staked out estates round Ice Fjord, Bell Sound and elsewhere, not infrequently regardless of one another's claims. Spitsbergen was then a No-Man's



FIG. 20.—Coal-bearing region of Central Spitsbergen

*B.* Barentsburg, Dutch mine. *R.* Radio Station and Government Headquarters. *G.* Grumant, Anglo-Russian mine. *L.* Longyear, Norwegian mine. *H.* Hjorthamn, Norwegian mine. *B.C.* Bruce City, Prospective Scottish mine. *T.* Cape Thordsen, abandoned. Swedish phosphate mine and site of Swedish Meteorological Station, 1882-83. *C.B.* Cape Boheman, abandoned Norwegian and Dutch mine. *N.* Ny-Aalesund, Norwegian mine. *M.I.* Marble Island, abandoned English marble quarries. *E.* Ebeltoft Haven, German Meteorological Station, 1912-14. *S.* Sveagruvan, Swedish mine.

Land, outside the jurisdiction of any State. Anybody could have land for the taking : there was no permission to be sought, no fees or taxes had to be paid, and there was no protection for the claimant. If another jumped his claim, he had to deal with the situation as best he could. No State had authority to give redress. It became the practice for a claimant to land to notify his own Foreign Office of the extent of the estate and to erect notice-boards on the land. Provided work was done the claim was generally respected, but as often as not the claim was abandoned and seized by a new prospector. On the whole this state of anarchy worked well. Disputes arose from time to time but they were generally settled amicably.

The earliest claims to land were Norwegian, but they were sold to a Sheffield company, which in 1904 started working poor Cretaceous coal at Advent Point. This venture failed after a few years, but an American company, which also acquired land from Norwegians on the opposite side of the bay in the same year, soon had a successful mine in operation. They ran an adit into the hillside and loaded coal at a small jetty. Longyear City of a dozen or so log houses soon became a busy centre. Other companies started later, some to prospect their estates in detail, others to work coal at prominent outcrops.

All the coal-bearing land that is easily accessible by reason of ice is now claimed by Norwegian, Swedish, Dutch and British companies. There are five mines in active operation and several companies still preparing to mine. A few abandoned mines denote hasty and ill-advised ventures.

Coal-mining in Spitsbergen is pursued under peculiar conditions, some advantageous and some the reverse. The gently inclined strata cut by deep fjords allow adits into the hillside from the mouths of which the coal is easily transported downhill to vessels lying close inshore in sheltered anchorage. The frozen soil obviates much use of pit props and prevents flooding. There is ample space for building. The summer daylight compensates for the winter darkness and the climate is magnificently healthy.

On the other hand all stores, material and labour have to be imported and the colliers must go north in ballast for want of freights. The shipping season is restricted to five or six

months in the year, and coal mined in winter must be stored for summer export.<sup>1</sup> Mining costs are naturally high although the taxes are very low under the new Norwegian regime. Spitsbergen coal-mining prospered during the European War owing to the soaring price of British coal, but even with lower prices it has continued with a yearly increasing output. The markets are in Norway, Sweden and Northern Russia, countries with little or no coal of their own. In Norway the use of Spitsbergen coal is spreading and a certain market is assured.

One of the chief factors in successful mining in Spitsbergen is to reduce the amount of labour required. In the larger mines coal-cutting machines have been introduced, and electric traction takes the coal to the mouth of the mine where it is automatically filled into buckets, each of 15 cwt. capacity, and carried on a wire ropeway to the loading jetty. In the largest Norwegian mine the coal is carried on a cable conveyor  $2\frac{1}{2}$  miles long with a capacity of 100 tons an hour, emptied from the buckets on to loading belts, and poured in a ceaseless stream in to the hold of the collier. The winter dump, with a storage capacity of 150,000 tons, is cleared at the same time by a five-ton grab, emptied into a shoot which distributes the coal along the belt. With modern colliers that require little or no trimming 4,000 tons can be loaded in a day. By the use of loading machinery and large vessels it is thus possible to export in less than half a year a full year's output of coal, and keep down the cost of freight.

It has been suggested that by the use of ice-breakers the Spitsbergen shipping season could be extended or even maintained throughout the year. The experiment was tried during the winter of 1926-7 with the use of one ice-breaker to enable vessels to enter and leave the mines in Ice Fjord and King's Bay. The value of ice-breakers has been proved in the Baltic, White Sea and elsewhere. They can easily break new ice even of several feet in thickness, and are regularly employed to keep open certain Finnish and German ports. In Spitsbergen an ice-breaker has been used to break through fast ice in the fjords at the beginning of the season, to allow the waiting colliers to reach the loading jetties. If the extent of ice to be broken is

<sup>1</sup> Two colliers managed to reach Norway from Spitsbergen in the middle of November, 1926.

narrow an ice-breaker would be useful to Spitsbergen shipping, but it must be remembered that though it effectually breaks the ice it does not remove it. The ice-breaker itself can get through, but the passage behind it is congested with broken ice which, if heavy and hard, may be dangerous, if not fatal, to an unprotected steel or iron vessel. Thus in midwinter, even if the darkness permitted safe navigation, an ice-breaker would not help shipping, but in spring when the floes are "rotting" it might be useful. The smashed ice is then too soft to be harmful unless a moving propeller strikes a large piece. A greater difficulty to shipping than fast ice in the fjords in spring is the occasional presence of moving streams of heavy pack off the west coast. These in bad ice years may occur in summer (p. 80). Though an ice-breaker could probably plough its way easily through such a stream, it would be powerless to keep open a passage for a vessel to follow in its wake. The experiment in Spitsbergen will be watched with interest. It is estimated that the cost of this service can be met by a toll of one krone, or about one shilling, per ton on the coal exported during the winter, but winter trade will also mean higher insurance rates and so dearer coal at that season.

The total output of coal in Spitsbergen was 1,500 tons in 1907, 38,400 in 1914, 100,000 in 1920, and 450,000 in 1924. The last two figures include about 20,000 tons from Bear Island, but work has now ceased on that coal-field. The number of men employed in the coal-fields is about 1,500 in winter and rather more in summer. They are mainly Norwegians, with a number of expert English and Scottish miners in more responsible positions. The capital so far invested in Spitsbergen coal mines is estimated to be over £4,000,000, divided between thirteen principal companies.

Other minerals are of less importance. Phosphatic rock, mica, and asbestos have been tried with no commercial success. Marble has been quarried but was found to be too friable. There has been talk of copper and zinc ores and wholly unfounded tales of gold. High grade iron ore exists in large quantities on Prince Charles Foreland, but is almost inaccessible over glaciers. The mountains of iron ore reported elsewhere some few years ago were imaginary. Lastly there are enormous deposits of exceptionally pure gypsum which

will probably be quarried before long. Thus as the hunting fails, a new and more permanent population is coming to Spitsbergen. In contrast to primitive barbarism of the hunter's hut, the mining camps are oases of civilization in Arctic wilds, with comfortable centrally-heated houses, recreation rooms, schools, churches, postal service, moving pictures, broadcasting, hospitals, and all the amenities of a modern town. The houses are built of double plank walls separated by an air space, with double windows. This is cheaper and more comfortable than log houses. They are often raised on wooden or concrete posts above the ground to escape the flooding of summer and the cold of winter.

Many of the engineers and firemen have their families in Spitsbergen, and several children claim it as their native land, in fact as the only one they know. Generally the men stay for a year and leave for Europe for a holiday or for good, but many return year after year and a few prefer never to leave the far north. The mining camps or "cities" are Östervaag, on Bear Island, now only a shadow of its former self and with its tiny railway idle for the time at least; Sveagruvan, a Swedish camp in Braganza Bay; Barentsburg, a large Dutch camp on Green Harbour near the big radio station and the headquarters of the new administration; Longyear City in Advent Bay, the largest camp and virtual capital in more ways than one; Hjorthamn, also in Advent Bay; Bruce City in Klaas Billen Bay, so far without a permanent population; Grumant, an Anglo-Russian camp near Coles Bay; and Ny-Aalesund, a busy Norwegian camp with short railway on King's Bay, the most northerly "city" in the world, and Amundsen's base in his famous flight.

## CHAPTER XXI

### COLONIZATION

#### III. The Canadian Archipelago

**T**HE islands lying north of continental North America are in the main a great area of Palæozoic rocks which were laid down on the submerged northern borders of the pre-Cambrian shield, the ancient crystalline rocks that occupy the interior and eastern parts of Canada and form the nucleus of the North American continent. On the east the Arctic archipelago, in much of Melville and Boothia peninsulas, in central Victoria Island, Baffin Island, Devon Island and Ellesmere Island, are areas of the pre-Cambrian rocks of the ancient shield land. These eastern parts, owing to the upward tilt of the shield, are the loftiest in the archipelago, rising to 5,000 and 6,000 feet in Baffin and Ellesmere Islands. The centre of the archipelago is lower, but in the west, elevations again reach 3,000 feet.

The Palæozoic strata of the archipelago are overlain in places by Triassic and Tertiary beds: all are nearly horizontal. Local depression, erosion and faulting have caused shallow arms of the sea to invade this low Arctic table-land and hence the many islands. The water in these channels is mostly under 100 fathoms, and by reason of their landlocked nature, they are very liable to become congested with pack-ice.

In the Carboniferous rocks of the archipelago several coal seams have been found in the Tertiary beds of Banks, Melville, Baffin and Ellesmere Islands, and elsewhere deposits of lignite. But none of these so far discovered is likely to prove of value except possibly in the exploitations of the deposits of copper. More than two centuries ago copper was reported in Arctic Canada, and it was one of the inducements that led several of the Hudson's Bay Company's men into the unknown north. Definite information about the deposits has been available only

in recent years. Many of the earlier travellers, as was so often the case with early explorers, had not the knowledge to give reports of any real value. Two large areas of copper-bearing rocks are now known, the one on the Coppermine River, the other in Bathurst Inlet. Further deposits occur in Boothia Peninsula, in the heart of Victoria Island, on Prince of Wales Island and to the east of Bathurst Inlet. These deposits are native copper in veins or amygdaloidal form in basalt flows in pre-Cambrian rocks. Sulphides of copper also occur. It is not improbable that this copper will eventually be worked on a large scale in the two mainland areas. Probably the easiest and cheapest transport would be via the Great Bear Lake and the Mackenzie River. Careful search may reveal other minerals of sufficient value to make it worth while overcoming difficulties of labour and transport. The Mackenzie River is becoming a more useful road every year and trading posts and settlements grow in number and will do so rapidly if the discoveries of oil around Norman on the lower river come up to expectations. It is not, however, in mineral wealth that lies the obvious future development of Arctic Canada.

One of the most striking features of the Arctic archipelago is the small extent of present glaciation. Only the larger islands to the east have any extensive ice-covered areas. For the rest the land is too low and the precipitation too slight to cause a permanent ice-covering. The greater part of the ice-free ground is clothed with prairie which is thinly covered with snow in winter but is free and open during the summer. The snowfall in the Canadian Arctic islands is, says Stefansson, less than half and, in many places, less than a quarter of what it is in Montreal or Leningrad (Petrograd) or on the hills around Oslo. It is less than in Chicago, Warsaw or the highlands of Scotland. But, of course, it lies longer on the ground, so that the prairies are not free for more than four months, and in the far north only two. The great herds of musk-ox and caribou prove that the conditions are not adverse to grazing animals. Cold and dark though the winter may be, these islands are not a lifeless desert.

In Alaska experiments in breeding reindeer have been highly successful. They were begun in 1892 with the introduction of a small herd of 170 reindeer from Siberia. Some



FIG. 21.—Arctic Canada—Native Preserves

I. Banks Island. II. Victoria Island. III. Peel River. IV. Yellowknife. V. Slave River. VI. Back's River.

Siberian natives were brought to teach the Alaskan Eskimo the practice of reindeer-breeding, and a few years later, some Lapp families were also introduced. More deer were imported annually for a few years and the herds thrived wonderfully. Their numbers doubling in three years' time, there are now over 400,000 domesticated reindeer in Alaska. It is estimated by the United States Department of Agriculture that the grazing lands of Alaska can support between three and four million head of reindeer. The animals are bred for meat : each carcass runs to about 150 lbs. ; but by interbreeding with the wild caribou in the interior it is hoped to increase the size of the Alaskan reindeer. E. W. Nelson believes that in less than twenty years Alaska will produce 1,250,000 carcasses of deer a year, or the equivalent in weight of about 3,000,000 sheep, which would obviously be a valuable addition to the food resources of America.

This suggests what might be done in developing the grazing lands of Arctic Canada. The Dominion must always be under a debt of gratitude to V. Stefansson for his tireless repudiation of the libel which the old term " Barren Lands " confers on the Arctic mainland of Canada. The term is the outcome of years of ignorance, fear of northern latitudes, and an ancient policy, now happily reversed, of the Hudson's Bay Company in warning settlers off their hunting territories. The story of Alaska was the same. When, in 1867, it was bought from Russia, the purchase was most unpopular in the United States and was described as " several million dollars for a lump of ice." Alaska became known as Seward's folly, W. H. Seward being the American statesman who was wise enough to see that Alaska was cheap at £1,450,000, quite apart from its gold mines which were not foreseen in his day. The prairies of the so-called Barren Lands are over a million square miles of grazing land over which herds of caribou and musk-ox roam. And their importance lies in the fact that while the pastoral lands of the world in lower latitudes always tend to give way to the advance of cultivation as the demand for cereals grows, the Arctic prairies have too poor a soil and too short a summer for the cultivation of food crops, and so must remain grazing lands for the beasts adapted to the specialized conditions. Since the tendency throughout the world is for more land to

be devoted to food crops and less to grazing, the response to the demands for cereals can be met only by the curtailment in the supply of meat unless new grazing lands are brought within the area of commercial exploration.

Yet it is easy to exaggerate the productiveness of the Arctic prairies: no real estimate of their value can be obtained, as has been suggested, by a statement of the number of species of flowering plants that occur there. Many of those plants are of little or no use to grazing animals, others are rare and of local occurrence, while nearly all are of slow and dwarfed growth and have no quick methods of reproduction. Overgrazing would quickly exhaust these prairies and necessitate many years for recovery. The wide roaming of the herds of caribou and musk-ox and the irregularity in their routes is probably due to their exhausting two or three years' growth of fodder in passing over any but the richest grazing grounds. Their migration in herds has perhaps led to exaggerated estimates of the total number of these animals by calculations based on the number observed in a square mile. Nor must it be overlooked that the thriving Alaskan reindeer industry is in the south and west where the vegetation is more luxuriant and quicker growing than in the Arctic plains, and that in those areas the wild caribou had been largely exterminated. An Eskimo population was waiting and eager to find a new form of livelihood after the exhaustion of the fur and game resources. But if conditions are not quite parallel between Alaska and Arctic Canada there is yet justification for drawing some analogies. Stefansson may in his enthusiasm have overstated his case, but he is not wrong in his main principles.

The reindeer lives mainly on grass in summer and on lichen in winter. There are nearly ten times as much grass as lichen in the Arctic prairies. So that the number of reindeer that the grazing can support is limited by the winter feed, while a great part of the summer feed must remain surplus. To utilize the grazing lands to the full Stefansson suggests that musk-ox or ovibos should be bred along with the reindeer, the musk-ox feeding solely on grass. He points to the facility with which wild caribou can be incorporated in herds of domestic Siberian reindeer as evidence that no great length of time would be required to domesticate the wild musk-ox. Within the life-

time of one generation, he believes, a herd could be tamed. Experiments alone can prove this.

Meanwhile the Hudson's Bay Reindeer Company, a subsidiary concern of the Hudson's Bay Company, in conjunction with Stefansson, acquired from the Canadian Government a lease for 50 years of 110,000 square miles in the south of Baffin Island. Five hundred reindeer from Norway were liberated there in 1921. Conditions are favourable for the rapid increase of the herds. Reindeer need no shelter from weather, but must be protected both from wolves and from the mingling of wild caribou in numbers large enough to make the herds unmanageable. Besides the supply of venison there will be the output of valuable hides, but of course there is no wool, and milk production is slight.

Stefansson estimates that Arctic grasslands, including the Siberian tundra, are capable of supporting 100,000,000 reindeer, and perhaps five times as many musk-ox. Leaving out of account Siberia it may be said on a safe estimate that Arctic Canada with its islands could support 30,000,000 reindeer and eventually yield perhaps 10,000,000 carcasses of venison a year. But this, of course, would take time, and the industry could develop only slowly as demands for meat grew and means of transport were developed.

Alaskan experience shows that a herd of 10,000 reindeer can be looked after by six Eskimo and a white manager. The industry would not therefore support a very large population, although the export of meat and musk-ox wool would employ a certain amount of labour, but when the game and fur-bearing animals fail in Arctic Canada as they have failed in Alaska, thanks to modern weapons, reindeer- and musk-ox-breeding may save the remnants of Eskimo population from starvation and give it a position of economic stability, without abandonment of the nomadic life.

## CHAPTER XXII

### HYGIENE

**I**N the light of experience and knowledge the old time fear of polar climates has vanished, even if there remains a popular impression that polar exploration entails hardships of no mean order. The ill-effect of the climate was in time narrowed to the occurrence of scurvy. It worked havoc among the Russian trappers in Spitsbergen in the eighteenth century. Hardly any escaped, and whole crews succumbed to it. Scurvy was supposed to haunt Spitsbergen in human form, as an old woman with eleven sisters who roamed the land in winter storms, spreading destruction as they went. Sleepiness was recognized as one of its symptoms, and to overcome the inclination to sleep the trappers undertook all kinds of futile work such as tying and untying knots again and again or playing the most childish games.

In the nineteenth century it was the scourge of polar expeditions, and in the lack of knowledge various useless measures were taken to counteract it. Probably it was scurvy that led to the loss of the entire Franklin expedition on a relatively easy march to safety, and it was the bane of most of the Franklin search expeditions. The one reliable preventive was supposed to be lime-juice, which was also used on British deep water ships, hence called by American sailors "lime-juicers." But its effectiveness was very doubtful. The whalers also suffered from scurvy, and if caught in the ice for the winter generally lost several men. There were whalers scarcely able to muster enough able-bodied men to work the ship after a winter's imprisonment in the ice. American whalers who made a practice of wintering at Herschel Island employed native hunters to procure a supply of fresh venison in order to keep the crews in good condition and free from scurvy.

Antarctic expeditions have had less experience of scurvy,

for none wintered till recent years, when they were armed with the knowledge of how to avoid it, and have generally taken the necessary precautions.

Scurvy is now known to be one of the deficiency diseases caused by the lack of certain vitamins in food. In other words, it is due to the lack of fresh food, and is caused by a diet of preserved meat, vegetables, etc., whether tinned or salt. It is not peculiar to polar regions, but can occur anywhere if the wrong diet is used. A deficiency of Vitamin C, as it is named, is also responsible for certain infantile troubles. This particular vitamin is widely spread, and though found particularly in fruit and vegetables, cannot be absent in meat. It is easily destroyed by oxidation, hence food should be fresh. The trapper and explorer of the past got scurvy as the price of their reliance on preserved provisions and their neglect of the food resources around them. Exercise, recreation and even lime-juice could not prevent it. The former are useless in themselves, and the latter has a modified value which disappears with time. Fresh lemon juice is far more valuable. Rae, Nansen, Leigh Smith, Bruce and Stefansson have each proved that a diet of fresh food, even if lacking in vegetables, is a safeguard against the disease. Russian trappers had a glimmering of the truth when they ate the leaves of sorrel and scurvy grass and drank reindeer blood as palliatives or preventives. Lapps value berries for the same reason. Apparently Eskimo rarely suffer from scurvy and their diet is almost wholly one of meat, blood and blubber, much of it undercooked or even raw. According to Rink only three deaths in 4,770 could be attributed to scurvy among the Greenlanders during the period from 1782 to 1853. Even allowing for faulty diagnosis and want of information in many cases this suggests a negligible incidence of the disease. It is no exaggeration to say that in the light of modern knowledge the occurrence of scurvy on a polar expedition is an indication of faulty organization and bad leadership. The one exception is in a long march over the ice-cap of Antarctica, where there are bound to be difficulties in the transport of fresh food.

The air of polar regions is free from injurious bacteria, and this sterility frees the traveller from a host of ills to which he is liable in crowded lands. Even to catch a cold in the ordinary

sense of the term is impossible. One can with impunity take risks that in civilization would lead inevitably to a cold and probably pneumonia. Colds are introduced to polar expeditions only when bales of clothing packed at home are opened; then the germs find easy lodgment in men who have lost a great measure of immunity to attack by long freedom from infection. D. MacMillan records how even the arrival of the mail at Etah caused an outbreak of colds. For the same reason one of the risks of polar exploration is the return to civilization. At the first port of call a number of the men are sure to take bad colds and possibly other infections. As an illustration of the immunity from germinal diseases enjoyed in polar regions, there may be cited the isolation hospital which was built at Longyear City in Spitsbergen when the coal mine was opened some twenty years ago. For years it was a deserted building and then for want of other use was converted into an oil store.

While temporary visitors enjoy this freedom from disease in polar regions, the permanent inhabitants, the Eskimo, experience the reverse. Introduced diseases, that come with the white man, have played havoc with a people who had no immunity from the ills of civilization. Bronchial troubles, tuberculosis, influenza, rheumatism and venereal diseases are rife among the Eskimo and are a significant cause in their reduction in physique and numbers.

Snow blindness is an affliction which is difficult to avoid without great precaution. It comes from the glare of the snow and ice and particularly from straining the eyes when travelling in mists or overcast weather. One eye may be affected at a time, but generally both suffer. It is a disease that one does not outgrow. One attack seems to predispose to another, and Eskimo suffer a great deal. The preventive is to wear amber-coloured glasses with close-fitting sides like motor-goggles. They are much more effective than smoked glasses, which, moreover, obstruct clearness of vision and make it difficult to see inequalities of the ground. Eskimo use wooden protectors with a narrow slit to admit the light. Snow blindness is very painful, but fortunately it does not seem to leave any permanent injury to the eye.

Frostbite is an exaggerated chilblain and may be very

serious, necessitating amputation and even leading to fatal results. When treated immediately on occurrence, however, it is not serious. Minor frostbites on face and hands are impossible to avoid when travelling in low temperatures. They are more serious on the toes, where they generally indicate a poor circulation, and in any case are not so readily noticed. The cure is gradual, but never sudden warming; a warm hand applied to the face will cure a minor frostbite. Rubbing is useful but if too vigorous may remove the skin, and rubbing with snow is never resorted to except in the pages of novelists.

Every one who has been to polar regions knows the feeling of exhilaration and exuberant health they give. There is no tendency to lassitude, no disinclination to effort. Body and mind are stimulated and tuned to a high pitch. A comparable feeling is experienced in alpine climates in lower latitudes. The years fall away, youth returns and active living is a joy.

Even the winter cold is no drawback. It is easy to dress suitably and yet lightly enough not to impede active movement. Men who know the cold soon get to like it and prefer polar climates to any others. After all it is seldom colder, except on the high plateaus, than in eastern Canada or Siberia.

The winter darkness is depressing at first and may lead to cases of melancholia, but it has not the terrors with which it is popularly endowed. Many Eskimo even regard it cheerfully, provided they have accumulated stores of food, as a period of rest and recreation, when the work of hunting nearly ceases and there is time for visits and gaiety. In the Spitsbergen mining camps most of the men prefer winter to summer. It is difficult however to regard the darkness with the indifference and even eagerness which Stefansson expresses, since the absence of sunlight must inevitably have a physiological effect which is not beneficial and has only partial compensation in the summer daylight. The pallid complexions of winterers are a sign that physiological conditions are abnormal.

Yet it has been the experience of nearly all expeditions that if there is neither scurvy nor starvation, the men improve in bodily health. Even when the strain of hardship has been great there are few instances of men, originally without constitutional defects, suffering any lasting ill-effects. The mining

population of Spitsbergen supplied with an adequate ration of fresh food is notably free from serious illness of any kind.

The healthiness of polar climates has been variously explained. Beneficial qualities have been attributed to differences in atmospheric pressure, low humidity, chemical purity, absence of bacteria and ionization of the air. The true explanation has yet to be found. Meanwhile it is of interest to note that with regard to alpine climates which have much the same effect on human beings, Dr. L. Hill, in a recent work,<sup>1</sup> finds the important factors are (a) lack of microbes, smoke and dust, (b) low relative humidity which promotes evaporation from the skin and lungs, (c) high drying power, (d) stimulation of the skin by cool air, and (e) abundant bright sunshine. He attributes no beneficial influence to atmospheric pressure in promoting a sense of well-being. If this is so, the low pressure of Alpine climates has no more influence than the relatively high pressure of polar regions.

There must be risks in exploration, but fatalities in many instances mark uncalled-for temerity or faulty organization. The more experienced the leader and his men, the less sensational will be the story they have to tell. The great disasters that have occurred in the past have mainly been due to errors of judgment, inexperience or preventable ill-health; a few, like the loss of Scott and his companions on the return from the South Pole, to bad luck and unavoidable strain. The polar regions are not inhospitable to those who live wisely: the mortality of the last half-century of effort is probably not more than three per cent, yet it is doubtful if Stefansson's title of "friendly" can be applied to the Arctic as a whole, though it is true of parts: certainly it is inapplicable to the wastes of snow and ice in the Antarctic.

There is another side to experience in polar regions, and that is the fascination it casts over the explorer. As the sailor longs for the sea, so does the polar explorer long for the ice. Very few men who have been to the Arctic or Antarctic do not contrive to return, and the history of polar exploration shows that most explorers have made several voyages. This would be the readier of explanation if exploration were a profession, but it is the reverse: it tears a man away from his profession

<sup>1</sup> L. Hill, *Sunshine and Open Air* (1925).

to interests that are shared by few and it leaves him stranded on his return. Yet no sooner has he found a new niche in civilization than he longs to be off once more and is eager to sacrifice all his prospects for another voyage to the ice. Many of us know the almost intolerable longing for just one more sight of the pack ; many of us have succumbed to the temptation and now, with passing years and decreasing opportunities, bewail our luck that chances seem to come no more.

It may be the fine free healthy life, or the freedom from care and worry, or perhaps the quiet and the beauty, or it may be the good comradeship and the close friendship, any or all of these reasons may explain the longing for the ice and the spirit of unrest it invokes. There may be other reasons too. But it never passes. It is the price that the polar explorer has to pay.



## BIBLIOGRAPHICAL APPENDIX

### REFERENCES

In the following list there is no attempt at completeness. As far as possible, books and papers have been selected that are likely to be accessible in good libraries. The bibliographies appended to many books and papers quoted will assist in further reading. The list includes only a small proportion of the works consulted. General works which only incidentally touch polar regions are seldom included.

*G.J.* = *Geographical Journal*.

*S.G.M.* = *Scottish Geographical Magazine*.

*G.R.* = *Geographical Review* (New York).

*Med. om Grön.* = *Meddelelser om Grönland* (Copenhagen).

*Ann. de G.* = *Annales de Geographie* (Paris).

*La G.* = *La Geographie* (Paris).

*P.M.* = *Petermann's Mitteilungen* (Gotha).

### MAPS

Only a few of the more general maps are mentioned. Detailed maps of small areas are to be found in the volumes describing the work of various expeditions. For seas and coast regions there is nothing to equal British Admiralty Charts, which are continually revised in the light of new knowledge.

#### Arctic.

##### GENERAL.

Admiralty Chart, North Polar Chart, two sheets.

Bartholomew's North Polar Regions in *Times Atlas* (1922).

Stanford's Arctic Regions, *London Atlas Series* (N.D.).

Arctic Regions, American Geographical Society (1912).

*Steiler's Hand Atlas*, Nord-Polar-Karte, with enlarged insets (1925).

Admiralty Chart, No. 2282 (Greenland Sea).

##### CANADIAN ARCTIC.

North-West Territories (Natural Resources Intelligence Service, Ottawa, 1924), 60 miles to 1 inch.

Various Admiralty Charts and Maps of Canadian Arctic Expedition, 1913-18.

#### GREENLAND.

Atlas with Vols. LX and LXI, *Meddelelser om Grönland*, "Grönland i Tohundredaaret" (1921).

Kort over Grönland, four sheets, 1 : 2,000,000 (1906), North-east Sheet only, revised, 1918.

#### NOVAYA ZEMLYA.

Russian Marine Ministry Charts in addition to British Admiralty Chart, No. 2962.

#### FRANZ JOSEF LAND.

Admiralty Chart, No. 2282.

#### BARENTS AND KARA SEAS.

Admiralty Chart, No. 2962.

#### SPITSBERGEN.

Admiralty Chart, No. 2751, and several others.

Norges Skökartverk, Chart No. 303 (outline), 1 : 1,000,000.

Spitsberg (Partie Nord-Ouest), G. Isachsen, 1 : 200,000 (Kristiania, 1915).

Prince Charles Foreland, W. S. Bruce and J. Mathieson, 1 : 140,000 (1913).

### Antarctic.

#### GENERAL.

Admiralty Charts, Antarctic Regions, eight sheets, Nos. 3170-3176 and 3206.

Bartholomew's South Polar Regions in *Times Atlas* (1922).

Stanford's Antarctic Regions, *London Atlas Series* (N.D.).

*Steiler's Hand Atlas*, Süd-Polar-Karte, with insets (1925).

#### VICTORIA LAND.

Especially results of *Discovery* and *Terra Nova* expeditions.

#### GRAHAM LAND AND ISLANDS.

Especially results of *Belgica*, *Antarctic*, *Français* and *Pourquoi Pas?*, Admiralty Chart, No. 3205 (S. Shetlands). No. 1238 (S. Orkneys) is now withdrawn.

#### WILKES AND ADELIE LAND.

Results of Australasian expedition in *Aurora*.

#### SOUTH GEORGIA.

Admiralty Chart, No. 3579.

#### KERGUELEN.

Maps, general and detailed, in *La Geographie*, XXXVII, No. 1, Jan., 1922. Admiralty Chart, No. 2398.

#### HEARD ISLAND, CROZETS AND PRINCE EDWARD ISLAND.

Admiralty Chart, No. 802.

## BOOKS AND PAPERS

## CHAPTER I. POLAR REGIONS

For a short general introduction to polar regions there is no better book than W. S. Bruce, *Polar Exploration* (1911). Older books of value are W. Scoresby, *An Account of the Arctic Regions* (1820); G. Hartwig, *The Polar World* (1874); A. E. Nordenskiöld, *The Voyage of the "Vega"* (1881); and K. Fricker, *The Antarctic Regions* (1900). O. Nordenskiöld, *Le Monde Polaire* (1913) is very condensed. Handbooks of value for older work are *Arctic Manual and Instructions* (1875) and *The Antarctic Manual* (1902). For more practical aspects, see *Practical Hints to Scientific Travellers*, edited by H. A. Brouwer, II (Leyden, 1924), which contains a number of articles on north polar lands by experienced travellers. Some of the advice shows distinct Scandinavian bias although the book is written in English and printed in Holland, and presumably is not offered solely to Norwegian readers. An article by V. Stefansson on "Erroneous Ideas of the Arctic," *G.R.*, April, 1922, reprinted as an appendix to his *The Northward Course of Empire* (1922) corrects some erroneous ideas prevalent with regard to polar regions, and most particularly the Arctic islands of northern Canada.

## CHAPTER II. ARCTIC EXPLORATION

The best history of Arctic exploration is A. W. Greely, *Handbook of Polar Discoveries* (1909). There are many popular compilations, inspired mainly by Peary's achievement in 1909, but as a rule they lack authority and balanced judgment. The accounts of various expeditions and lives of prominent explorers must be consulted for details. F. Nansen, *In Northern Mists* (1911), gives a scholarly account of exploration up to the sixteenth century.

## CHAPTER III. ANTARCTIC EXPLORATION

The only satisfactory history of Antarctic exploration is H. R. Mill's *The Siege of the South Pole* (1905). For later work the narratives of various expeditions must be consulted. See also W. S. Bruce, "The Weddell Sea: An Historical Retrospect," *S.G.M.*, June, 1917. The recently revised volumes of *Admiralty Sailing Directions*, dealing with Antarctic seas, contain much carefully compiled information. Some of the inner history of recent organization and endeavours will be found in H. R. Mill, *The Life of Sir Ernest Shackleton* (1923), and R. N. Rudmose Brown, *A Naturalist at the Poles* (1923), which is a life of W. S. Bruce. Two older works were published before the important expeditions of this century,

but have some value, K. Fricker, *The Antarctic Regions* (1900), and E. S. Balch, *Antarctica* (1902). "The Scott Tragedy," R. E. Priestley, *G.J.*, October, 1926, is a critical analysis of the causes of that disaster.

#### CHAPTER IV. POLAR CLIMATES

Volumes on the scientific results of various polar expeditions, especially those of Nansen, Amundsen, Gerlache, Bruce, Charcot, Scott, Shackleton, Drygalski, Sverdrup, etc. For the Antarctic climate, see particularly G. C. Simpson, *British Antarctic Expedition*, 1910-13, *Meteorology* (1919), and *Scott's Polar Journey and the Weather* (Oxford, 1926); R. C. Mossman, "Physical Conditions of the Weddell Sea," *G.J.*, December, 1916. W. H. Hobbs, *The Glacial Anticyclones* (New York, 1926), is useful for the exposition of the theory with copious references to polar meteorology. For changes of climate, see C. E. P. Brooks, *The Evolution of Climate*, 1924, "The problem of warm polar climates," *Quart. Journ., Roy. Met. Soc.*, 51 (1925), and *Climate through the Ages* (1926). For the theory of the "polar front," see V. Bjerknes, *Geofysiske Publikationer*, Kristiania, II, 4 (1920), and III, 1 (1922). Brief notes on the recent *Maud* expedition by H. U. Sverdrup is in *Scientific Monthly* (May, 1926) and *Monthly Weather Review*, 53 (1925), pp. 471-475.

#### CHAPTER V. OTHER ATMOSPHERIC PHENOMENA

For the most recent work on auroras, see papers by L. Vegard in *Philosophical Magazine*, XLII, p. 47 (1921), and XLVI, pp. 193 and 577 (1923); F. A. Lindeman, *Philosophical Magazine*, XXXVIII, p. 672 (1919); and C. Störmer in *Terrestrial Magnetism*, XXII (1917). Also K. Birkeland, *The Norwegian Aurora Borealis Expedition*, 1902-03 (1913); A. Angot, *Les Aurores Polaires* (1895), and reports of *British Antarctic Expedition*, 1910-13, *Observations on the Aurora*, C. S. Wright (1921), and *Australasian Antarctic Expedition*, 1911-14, *Records of Aurora Polaris*, D. Mawson (Sydney, 1925).

#### CHAPTER VI. SEA ICE AND ITS NATURAL HISTORY

See various works by F. Nansen and others quoted under Chapter VIII. Also V. Stefansson, *The Friendly Arctic* (1921); J. K. Davis, *With the Aurora in the Antarctic* (1919); W. S. Bruce, *Polar Exploration* (1911); R. N. Rudmose Brown, *A Naturalist at the Poles* (1923); R. E. Priestley, *British Antarctic Expedition*, 1910-23, *Glaciology* (1922); J. M. Wordie, "The Natural History of Pack-ice in the Weddell Sea," *Trans. Royal Soc., Edinburgh*, LII, iv, No. 31 (with bibliography); and R. W. James, "Some

Problems Relating to Antarctic Sea Ice," *Manchester Memoirs*, LXVIII, 7 (1924).

## CHAPTER VII. THE ARCTIC OCEAN: BASIN AND COASTS

References to geomorphology are scattered in various works dealing with the subject as a whole, such as E. Suess, *The Face of the Earth* (1904); G. Schott, *Geographie der Atlantischen Ozean* (Hamburg, 1912); and many purely geological works. Also F. Nansen, "Oscillations of Shore Lines," *G.J.*, December, 1905, and particularly his *Strandflat and Isostasy* (Kristiania, 1922) (with full bibliography); reports of *Norwegian Arctic Expedition*, 1893-96; O. Holtedahl in *Report of Sci. Res. of the Norwegian Expedition to Novaya Zemlya*, 1921-22 (Oslo, 1924) (with valuable bibliographies for all Arctic lands); and R. A. Daly, "Pleistocene Changes of Level," *American Journal of Science*, October, 1925, which includes a statement of various estimates of changes in sea-level due to melting of the ice-caps.

## CHAPTER VIII. ARCTIC CURRENTS AND ICE

On currents and ice important papers and works are F. Nansen, *Northern Waters* (Kristiania, 1905); *Spitsbergen Waters* (Kristiania, 1915); *Hunting and Adventure in the Arctic* (1925); *En Ford till Spitsbergen* (Kristiania, 1920) and Reports of the *Norwegian Arctic Expedition*, 1893-96; F. Nansen and B. Helland-Hansen, *The Norwegian Sea* (Bergen, 1909); E. Mikkelsen in *Med. om Grön.*, LII (1915); L. Koch, "Ice-cap and Sea Ice in North Greenland," *G.R.*, January, 1926; and R. C. Mossman, "The Greenland Sea," *S.G.M.*, June, 1909. *The State of the Ice in the Arctic Seas* is an annual publication of Det Danske Meteorologiske Institut: also *Summary and Average Limits* (Copenhagen, 1917). "Arctic Ice," C. I. Speersneider, *Marine Observer*, May, 1926, is a useful popular summary, and a paper by H. Ette, "East Greenland," *Geographical Teacher*, Autumn, 1925, is by one of the most experienced of living ice-masters. See also Chapter VI, Sea Ice.

## CHAPTER IX. THE ANTARCTIC CONTINENT

See the geological results of all recent Antarctic expeditions, especially T. W. Edgeworth David and R. E. Priestley, *British Antarctic Expedition*, 1907-09, *Geology I* (1914) (with references to all earlier papers of importance); F. Debenham, R. E. Priestley and others in *British Antarctic Expedition*, 1910-13, various volumes; O. Nordenskjöld, *Wissen. der Schwedischen Südpolar Exped.*, I, i (1911); also W. S. Bruce, *Ueber die Fortsetzung. des Antarktischen*

*Festlandes, etc.* (Edinburgh, 1910); A. Penck in *Zeit. d. Gesell. für Erdkunde*, 3 (1910); J. W. Gregory, "The Structural and Petrographic Classification of Coast Types," *Scientia*, XI, 21 (1912); J. M. Wordie, "Geological Observations in the Weddell Sea Area," *Trans. Royal Soc., Edin.*, LIII, 2 (1921); D. Ferguson, J. W. Gregory and G. W. Tyrrell, various papers on South Georgia, etc., in *Trans. Royal Soc., Edin.*, L, LI, LII, LIII (1915-21); D. Mawson, "The Australasian Antarctic Expedition," *G.J.*, June, 1911.

#### CHAPTER X. THE ANTARCTIC OCEAN: CURRENTS AND ICE

Volumes of various expeditions, particularly those mentioned as paying attention to oceanography; also J. K. Davis, *With the Aurora in the Antarctic* (1919); W. S. Bruce, "Bathymetrical Survey of the South Atlantic Ocean and Weddell Sea," *S.G.M.*, August, 1905; W. Brennecke, "Die Ozeanographischen Arbeiten der Deutschen Antarktischen Expedition, 1911-12," *Arch. der Deutschen Seewarte*, XXXIX, 1, 1921; R. C. Mossman, "Physical Conditions in the Weddell Sea," *G.J.*, December, 1916; J. M. Wordie, "The Drift of the *Endurance*," *G.J.*, April, 1918; "The Drift of the *Aurora*," *G.J.*, September, 1921. See also references under Chapter VI, Sea Ice.

#### CHAPTER XI. ICE SHEETS AND GLACIERS

The glaciology of the Antarctic continent has already a considerable literature in the results of various expeditions of the present century. See especially *British Antarctic Expedition, 1907-09, Geology, Glaciology, etc.*, I (1914), and *British Antarctic Expedition, 1910-13, Glaciology* (1922), and other volumes in the series. These volumes contain full bibliographies. Also O. Nordenskjöld, *Wissen. der Schwedischen Südpolar Expedition*, I, i (Stockholm, 1911). For the Arctic the papers are more scattered. *Med. om Grön.* is invaluable for the reports of all Danish expeditions (with summaries in French); also A. de Quervain's *Quer durchs Grönlandseis* (Munich, 1914); E. von Drygalski, *Grönland Expedition* (1897); A. de Quervain and P. L. Mercanton, "Erg. der Schweiz. Grönland Exped.," *Mem. Soc. Helv. Sc. Nat.*, LIII (1920), and L. Koch, "Ice-cap and Sea Ice in North Greenland," *G.R.*, January, 1926.

For Novaya Zemlya see O. Holtedahl and O. T. Grönlie in *Report of the Scien. Res. of the Norwegian Exped.*, 1921 (Oslo, 1924); for Jan Mayen, J. M. Wardie, *G.J.*, March, 1922, and P. L. Mercanton, "La première ascension du Beerenberg," *Echo des Alpes*, No. 8, Lausanne, 1924.

For Spitsbergen the papers are too numerous to list. G. W.

Tyrrell, "The Glaciers of Spitsbergen," *Trans. Geol. Soc., Glasgow*, XVII, 1, 1922, has a useful bibliography. See also J. M. Wordie, "Present Day Conditions in Spitsbergen," *G.J.*, July, 1921, and for North-East Land, F. G. Binney and others, *G.J.*, July and August, 1925.

Several general volumes are useful, including W. H. Hobbs, *Characteristics of Existing Glaciers* (1911); W. B. Wright, *The Quaternary Ice Age* (1914), and A. P. Coleman, *Ice Ages* (1926).

## CHAPTER XII. POLAR VEGETATION

Many volumes of polar travel contain lists of plants, but contributions descriptive of vegetation are not so numerous. For Greenland see R. Brown, "Florula Discoana," *Trans. Bot. Soc., Edin.*, IX, 2 (1867), and *Arctic Manual and Instructions* (1875); R. E. Holttum, "The Vegetation of West Greenland," *J. of Ecology*, X, 1 (1922); C. H. Ostenfeld, "Flora and Fauna of North Greenland," in K. Rasmussen, *Greenland by the Polar Sea* (1921), and papers by C. H. Ostenfeld, M. P. Porsild and others in various volumes of *Med. om Grön.* For Spitsbergen see G. Andersson and H. Hesselman, "Spetsbergens och Beeran Eilands Kärleväxt flora, etc.," *Bih. K. Svensk. Vet. Akad.*, XXVI (1900); H. Resvoll-Holmsen, "Observations botaniques," *Rés. des campagnes scientifiques accomplies par Albert Ist*, XLIV, 5 (Monaco, 1913); T. Wulff, *Botanische Beobachtungen aus Spitzbergen* (Lund, 1902); V. S. Summerhayes and C. S. Elton, "Contributions to the Ecology of Spitsbergen," *J. of Ecology*, XI, 2 (1923) (with bibliography).

For the Canadian Arctic see H. G. Simmons, "A Survey of the Phytogeography of the American Arctic Archipelago," *Lunds Univers. Arskr.*, XI (1913); and T. Holm, "Contributions to the Morphology, Synonymy and Distribution of Arctic Plants," *Report of the Canadian Arctic Expedition*, 1913-18, V B (1922) (with general bibliographies).

For Antarctic and sub-Antarctic vegetation see W. B. Hemsley, *Reports of "Challenger" Expedition, Botany* (1885); C. Skottsberg, "Some remarks on the geographical distribution of vegetation in the colder southern hemisphere," *Ymer* (1905), and various papers in *Wissen. Ergeb. der Schwedischen Südpolar Exp.* (Stockholm, 1905-19); R. N. Rudmose Brown, "The Problems of Antarctic Plant Life" and other papers in *Sci. Res., Scot. Nat. Ant. Exp.*, III (1912) (with bibliography); C. Chilton and others, *Sub-Antarctic Islands of New Zealand* (Wellington, 1909), and T. F. Cheeseman, "The Vascular Flora of Macquarie Island," *Reports of Australasian Antarctic Exp.*, 1911-14, C. VII, 3 (Sydney, 1919) (with bibliography of sub-Antarctic islands), and ditto C. VII, 5.

## CHAPTER XIII. ARCTIC ANIMAL LIFE

There is a library of volumes that deal with or touch on Arctic natural history. The works of V. Stefansson, K. Rasmussen, O. Sverdrup, F. Nansen, elsewhere referred to are useful. F. Nansen, *Hunting and Adventure in the North* (1925) contains the best accounts of the polar bear and the chief Arctic seals. H. Rink, *Danish Greenland* (1877), tells of Eskimo hunting in happier days, and V. Stefansson, *Hunters of the Great North* (1923), is full of Eskimo hunting lore. See also his "Living off the Country" in *G.R.* (New York), May, 1919. Papers by R. Brown on "The Mammalian Fauna of Greenland, the Seals of the Spitsbergen and Greenland Seas, and the Cetacea of Davis Strait," which appeared in the *Proceedings of the Zoological Society* in 1868, were reprinted with additions in the *Arctic Manual* (1875), which is a mine of information. J. Lamont, *Seasons with the Sea Horses* (1861) is about Spitsbergen hunting, and A. Koenig, *Avifauna Spitzbergensis* (1911) is a full account of the birds, brought up to date by F. C. R. Jourdain, "Birds of Spitsbergen and Bear Island," *The Ibis*, January, 1922. "The Mammalia and Birds of Franz Josef Land," by W. S. Bruce, appears in *Proc. Roy. Phy. Soc., Edin.*, XIV, 1899. Records of Norwegian Arctic hunting are to be found in two long papers by G. Isachsen in *Det Norske Geografiske Selskaabs Aarbok*, "Fra Ishavet" (1918-19), and "Norske Fangstmaends Faerder til Grönland" (1922). For modern hunting see also W. G. Burn-Murdoch, *Modern Whaling and Bear Hunting* (1917) and, for a record of slaughter, The Duke of Orleans, *Hunters and Hunting in the Arctic* (1911). A. E. Nordenskiöld, *Voyage of the "Vega"* (1881) will always remain a classic on the European and Asiatic Arctic. *Med. om Grön.* contains numerous papers on Greenland fauna, including the birds, by H. Winge in Vol. 21 (1899). B. Digby, *The Mammoth* (1926), collects facts about mammoth ivory, and O. Holtedahl, *Report on the Scientific Res. of the Norwegian Exped. to Novaya Zemlya*, 1921 (Oslo, 1924), deals with that land.

Papers dealing solely with invertebrates are too numerous to mention.

## CHAPTER XIV. ANTARCTIC ANIMAL LIFE

For accounts of Antarctic animal life reference should be made to the records of all recent Antarctic expeditions, including their volumes of scientific results. A few are more important than others, including *The Heart of the Antarctic*, E. H. Shackleton (1909); *The Home of the Blizzard*, D. Mawson (1915), *The Worst Journey in the World*, A. Cherry-Garrard (1922); and the *Voyage of the "Scotia,"*

R. N. Rudmose Brown and others (1908). *Scientific Results of the Scottish National Antarctic Expedition*, Vol. IV (Vertebrates), is very full on birds and seals (with bibliographies), and Vol. IV (Zoological Log) is descriptive of all animal life. For the Falklands and dependencies see *Report of Interdepartmental Committee* (1920) and R. C. Murphy on "The Penguins of South Georgia" in *Science Bulletin* (Brooklyn), Vol. 2, No. 5, and other papers by the same author. For Macquarie Island see D. Mawson above, and for Kerguelen, etc., see H. N. Moseley, *Notes of a Naturalist on the "Challenger"* (1892), and R. du Baty's *15,000 miles in a Ketch* (N.D.). See also *The Antarctic Manual* (1901) and V. F. Boyson, *The Falkland Islands* (1924), which touches Antarctic sealing and bird life.

Papers on invertebrate fauna will be found in volumes of *Scientific Results of the Scottish National Antarctic Expedition* and *British Antarctic Expedition*, 1910-13. These contain the fullest accounts and useful bibliographies.

#### CHAPTER XV. THE ESKIMO

There are many books on the Eskimo, including H. Rink, *Danish Greenland* (1877) and *Tales and Traditions of the Eskimo* (1875), by the highest authority of his day; F. Nansen, *Eskimo Life* (1893); K. Rasmussen, *The People of the Polar North* (1908) and *Greenland by the Polar Sea* (1921); V. Stefansson, *My Life with the Eskimo* (1913) and *Hunters of the Great North* (1923); J. W. Bilby, *Among Unknown Eskimo* (1923). Among many important memoirs in *Med. om Grön.* may be mentioned "The Eskimo Tribes," H. Rink, XI (1887); "An Anthrogeographical Study of the Origin of the Eskimo," H. P. Steensby, LIII (1917), and references under Chapter XIX. See also F. Boas, "The Central Eskimo," *Report of Bureau of Ethnology*, 1884-5 (Washington, 1888); K. Rasmussen, "The Fifth Thule Expedition," *G.J.*, February, 1926; V. Stefansson, "Distribution of Human and Animal Life in Western Arctic America," *G.J.*, May, 1913; D. Jenness, "Life of the Copper Eskimo" and other papers in *Report on Canadian Arctic Expedition*, 1913-18, XII-XVI; H. T. Munn, "The Eskimo of Arctic Canada," *G.J.*, May, 1926, for the gloomy views of an experienced Arctic trader on the future of the Eskimo.

#### CHAPTER XVI. WHALING

Modern whaling is best described in W. G. Burn-Murdoch, *Modern Whaling and Bear Hunting* (1917); A. J. Villiers, *Whaling in the Frozen South* (1926); and J. J. Bell, *The Whalers*. Herman Melville, *Moby Dick*, describes the old-time sperm whaling in tropical

seas and so does F. T. Bullen, *The Cruise of the "Cachalot"* (1899). T. Beale, *The Sperm Whale* (1839) is still a standard volume. C. B. Hawes, *Whaling* (1924) is mainly a history of American whaling. The life of the Scottish and English whalers in Greenland waters is described in W. Scoresby, *An Account of the Arctic Regions* (1820); R. Brown, *The Countries of the World*, I (1885); C. E. Smith, *From the Deep of the Sea* (1922). J. A. Cook, *Pursuing the Whale* (1926) is an account of American whaling in Alaskan waters. The *Report of the Interdepartmental Committee on Research and Development in the Dependencies of the Falkland Islands*, Cmd. 657 (1920), is a fascinating blue book on all aspects of modern whaling and sealing in the south, and is worthy of a less repellent title.

#### CHAPTER XVII. POLITICAL GEOGRAPHY

References are scattered. Various volumes of *The Annual Register* are useful, especially 1922, 1923 and 1924, for the dispute between Norway and Denmark. For Spitsbergen see R. N. Rudmose Brown, *Spitsbergen* (1920), and "Recent Developments in Spitsbergen," *S.G.M.*, April, 1920; *Spitsbergen Treaty, Treaty Series*, No. 18 (1924); *Spitsbergen, Foreign Office Peace Handbooks*, No. 36 (1920), and *Spitsbergen-Norge*, G. Isachsen (Kristiania, 1921). For Wrangel Island see *G.J.*, December, 1923, and V. Stefansson, *The Adventure of Wrangel Island* (1926).

For both British dependencies in the Antarctic see "The Ross Dependency," *G.J.*, November, 1923, and *London Gazette*, July 31, 1923.

#### CHAPTER XVIII. TRADE ROUTES

The chief authorities on trade routes are the various volumes of Admiralty *Sailing Directions* and *Ocean Passages for the World* (1923). See also *The Marine Observer* (monthly) and any good atlas. Articles on Atlantic ice are "A Cruise with the International Ice Patrol," R. de C. Ward, *Monthly Weather Review* (Washington, February, 1924), and "Le danger des icebergs sur les routes maritimes de l'Atlantique Nord," C. Vaillaux, *Matériaux pour l'Etude des calamités*, No. 8 (Geneva, 1926). For the Kara Sea route see F. Nansen, *Through Siberia* (1914), and "The Siberian Sea Route" (with new map), N. A. Trausche, *G.R.*, July, 1925. For the Hudson Bay Route see A. H. Markham, "Hudson's Bay and Strait," *Supplementary Papers, Royal Geog. Soc.*, II, 4, 1889, and A. H. de Trémaudan, *The Hudson Bay Road* (1915) (with bibliography).

For Arctic flying and proposed air routes see R. Amundsen,

*My Polar Flight* (1925), and his new book on his successful voyage in 1926 ; G. Binney, *With Seaplane and Sledge in the Arctic* (1925), and V. Stefansson, *The Northward Course of Empire* (1922).

#### CHAPTER XIX. COLONIZATION : GREENLAND AND NOVAYA ZEMLYA

There is a whole library on the ancient settlements in GREENLAND. Reference may be made to F. Nansen, *In Northern Mists* (1911) (with a full bibliography) ; to papers by G. F. Holm, D. Bruun and others in various volumes of *Med. om Grön.*, and particularly Vol. LXVII of that publication with papers in English on the recent archæological researches of P. Nörlund and F. C. Hansen ; Vols. XXVII-XXX which deal entirely with various aspects of East Greenland (mainly in English) ; Vols. LX and LXI (1921) which is a complete survey, in Danish, with Atlas, entitled "Grönland i Tohundredaaret for Hans Egedes Landing" ; and Vol. LXIII for a paper on "The Mineral Resources of Greenland," by S. H. Ball. Modern Greenland appears incidentally in various books like F. Nansen, *The First Crossing of Greenland* (1890) and A. C. Seward, *A Summer in Greenland* (1922). H. Rink, *Danish Greenland* (1877), though out of date, is the best general book in English. *Peace Handbooks*, XXI, No. 132 (1920), is a useful compilation. Useful summaries of various researches in Norse archæology in Greenland appear in *Ann. de G.*, XXXV, No. 193 (1926), and *G.R.*, October, 1925.

There is little on NOVAYA ZEMLYA in English. A. E. Nordenskiöld's classic on *The Voyage of the "Vega"* (1881) is old but useful. See also *Report of the Scien. Results of the Nor. Exp. to Novaya Zemlya*, 1921, O. Holtedahl (Oslo, 1924).

The best book on KOLGUEV, with appendices on its natural history, is A. Trevor-Battye, *Icebound on Kolguev* (1895), and on FRANZ JOSEF LAND, F. G. Jackson, *A Thousand Days in the Arctic* (1899).

#### CHAPTER XX. COLONIZATION : SPITSBERGEN

SPITSBERGEN mining is described in full in R. N. Rudmose Brown, *Spitsbergen* (1920) ; A. Hoel, "The Coal Deposits and Coal Mining of Svalbard" in *Resultater av de Norske Statsunderstøttede Spits.*, I, 6 (Oslo, 1925), and H. M. Cadell, "Coal Mining in Spitsbergen" in *Trans. Instit. Mining Eng.*, LX, 2 (1920). Hoel's paper contains the mining regulations under Norwegian rule, and bibliography mainly of Norwegian works. M. Conway, *No Man's Land* (1906) gives the early history.

## CHAPTER XXI. COLONIZATION : CANADIAN ARCTIC ARCHIPELAGO

Many of the older writings on ARCTIC CANADA give a jaundiced view of its character and resources, though here and there are gleams of truth. Enthusiasm pervades V. Stefansson's books, *The Friendly Arctic* (1921) and *The Northward Course of Empire* (1922). See also O. Sverdrup, *New Land* (1904) ; J. E. Bernier, *The Arctic Islands and Hudson Strait* (Ottawa, 1910), both of which have useful appendices on geology and biology ; two small but useful pamphlets, *Canada's Arctic Islands* (Ottawa, 1923), and *Local Conditions in the Mackenzie Delta* (Ottawa, 1923) ; and papers by E. W. Nelson, "Reindeer in Alaska," Bulletin No. 1089, U.S. Dept. of Agriculture ; R. M. Anderson, "The Present State and Future Prospects of the Larger Mammals of Canada," *S.G.M.*, November, 1924 ; V. Stefansson, "Polar Pastures," *Forum*, New York, January, 1926 ; and D. M. Le Bourdais, "Meat from the Arctic," *Empire Review*, November, 1926. Recent geological work will be found in *Report of the Canadian Arctic Expedition*, 1913-18, XI, A, Geology.

## CHAPTER XXII. HYGIENE

Volumes of many expeditions contain reports by the medical officers. Reference may also be made to the narratives themselves.

# INDEX

(The bibliography is not included)

## A

*Active*, 27

Adelie Land : blizzards, 45 ; discovery, 25 ; French claim, 178

Air routes, Arctic, 187

Algæ, 122-123

Amarok, 129

Amdrup, G. C., 17

Amundsen, R. : Arctic flights, 19 ;

*Gjoa*, 12 ; ice near pole, 59,

74 ; *Maud*, 16 ; North-West

passage, 12 ; South Pole, 74

Andersson, J. G., 90

Andrée, S. A., 19

Angmagsalik, 151, 152, 171, 172

*Antarctic*, 29, 94, 98

Antarctic and Antarctica : Andes,

86, 90-91 ; anticyclone, 42-

46 ; areas, 1, 4, 83 ; birds,

140-143 ; climate, 33-46 ;

coasts, 83-94 ; continental-

ity, 25, 27, 84-85 ; crossing

of, 31 ; currents, 94-97 ; dis-

covery of, 23 ; first landing

on, 27 ; first wintering on,

28 ; flora, 119-121 ; former

connections, 88-89 ; icebergs,

97-98, 101 ; ice-sheet, 85,

99-105 ; nomenclature, 29,

83 ; observatories, 49 ; ocean,

93-98 ; seals, 138-140 ; struc-

ture, 84-92 ; territorial claims,

175-178 ; whaling, 162-166

Antilles, Southern, 86, 87, 91, 94

Arctic : areas, 1, 4, 64 ; birds,

135 ; climate, 33-46 ; cli-

matic changes, 47-48, 82 ;

continental shelf, 67-69 ; con-

trasts with Antarctic, 5, 18,

61, 118, 119, 138, 144 ; cur-

rents, 72-82 ; flora and plant

life, 112-119 ; icebergs, 78 ;

insects, 136 ; mammals, 126-

135 ; observatories, 49-50 ;

ocean, 66-67 ; police posts,

170-171 ; prairies, 213, 216 ;

seals, 130-134 ; strandflat,

69-71 ; territorial claims,

167-175 ; whaling, 157-162

*Archæocyathina*, 88

Area : Antarctica, 83 ; Arctic

drainage, 72 ; Arctic Ocean,

64 ; ice-covered sea, 81-82 ;

polar lands, 1, 4

Arrow Strait, 72

Atlantic, ice in, 77, 180-185

Auckland Islands, 179, 192

*Aurora*, 30, 94, 97

Aurora polaris, 51-54

## B

Back, G., 11

Bacteria, 114-115, 219-220

Baffin, W., 9

*Balaena*, 27, 139, 159

Balch, E. S., 23

Balleny, J., 24

Barents, W., 9

Barents Sea : currents, 80 ; dis-

covery, 7 ; extent, 64 ; ice

area, 82 ; navigation, 186

Barrier, Ice : *see* Ross Barrier

Barrier blizzards, 43-45

Beacon sandstone, 87, 88  
 Beardmore glacier, 102  
 Beaufort Sea, 64, 74  
*Belgica*, 28, 98  
 Bellingshausen, F. G., 24-25  
 Bennett Island, 111, 168  
 Bering Strait, 10, 12, 65, 77, 80, 185  
 Bernacchi, L., 102  
 Big Lead, Peary's, 74  
 Binney, G., 19  
 Bipolarity, 144  
 Birds : Antarctic, 141-143 ; Arctic, 135  
 Biscoe, J., 24  
 Bjerknes, V., 46  
 Blizzards, 42-46  
 Borchgrevinck, C. E., 27, 28, 102  
 Bouvet Island, 2, 22, 105, 179  
 Bransfield, E., 23, 175  
 Breitfuss, L., 81  
 Brooks, C. E. P., 48  
 Brown, R., on discoloration of sea, 122  
 Bruce, W. S. : Antarctic area, 83 ; — drift, 96 ; — structure, 90 ; — traverse plans, 31 ; pack-ice, 59-60 ; polar limits, 2 ; *Scotia* expedition, 29 ; Scottish Oceanographical Laboratory, 6 ; Scottish whalers, 27 ; sealers, 23 ; South Orkney observatory, 49, 175 ; Southern Ocean limits, 93  
 Bruce Land, 29  
 Buchan, D., 11  
 Burn-Murdoch, W. G., 27, 163  
 Burrough, S., 9  
 Byrd, R. E., 19

## C

Cabot's voyages, 8  
 Cagni, U., 14, 16  
 Caird coast, 29, 31  
 Caledonian folds, 66  
 Canada's Arctic claims, 170-171

Canadian Arctic Archipelago : area, 4 ; caribou and reindeer, 127, 215-217 ; Eskimo preserves, 171 ; exploration, 8-12, 14, 16, 17 ; flora, 118, 119 ; glaciation, 118, 213 ; musk-ox, 126, 214-217 ; police posts, 170-171 ; prairies, 213, 216 ; structure, 212, 213  
 Caribou : *see* Reindeer  
 Caribou, Eskimo, 153, 154  
 Carmen Land, 84  
*Challenger*, 26, 28, 94, 98  
 Chancellor, R., 9  
 Charcot, J., 29  
 Chukchee settlement, 169  
 Circles, polar, 1  
 Circumcision, Cape, 22  
 Climate, changes of, 47-48  
 Coal and coal mining : Bear Island, 26 ; Canadian Arctic, 212 ; Greenland, 199 ; Kerguelen, 124 ; Novaya Zemlya, 202 ; Spitsbergen, 206-211  
 Coats Land, 29, 31, 84, 85, 88, 90  
 Cold wall, 180  
 Collinson, R., 12  
 Continental shelf, 64, 67-69  
 Conway, Sir M., 9  
 Cook, J., 10, 22  
 Copper, native, 213  
 Crocker Land, 16, 17  
 Crops in Arctic, 116-117  
 Crozet Islands, 85, 105, 123, 177, 178  
 Cryolite, 198-199  
 Currents : Arctic, 72-82 ; Davis Strait, 76-77 ; East Greenland, 72, 75, 76, 78 ; Irminger, 75, 78 ; Kamchatka, 77 ; Kuro Sivo, 80 ; Labrador, 77, 180, 182 ; North Atlantic drift, 180, 182 ; North Cape drift, 180, 182 ; Ross Sea, 97 ; Southern Ocean, 95-98 ; Spitsbergen drift, 80 ; Weddell Sea, 61, 97  
 Cyclones, 41-43, 45, 46

## D

- Dallmann, E., 27, 169  
 Daly, R. A., 68  
 Danish explorers in Greenland,  
   17; — Meteorological Office,  
   81  
 Darkness, effect of, 221  
 David, E.: Antarctic structure,  
   87, 90; area of Antarctic,  
   83; South Magnetic Pole, 30  
 Davis, J., 9  
 Davis, J. K., 31, 88, 100  
 Dease, P. W., 11  
 Debenham, F., 87, 92, 102  
 Deception Island, 165  
 De Long, G. W., 16  
 Denmark: Arctic sovereignty,  
   171-173; care of Eskimo,  
   155, 197; East Greenland  
   and Norway, 171-172  
 Deshnev, S., 10  
*Deutschland*, 31, 61, 94  
*Diana*, 159  
 Diatoms, 122-123  
 Disco Arctic station, 198  
*Discovery*, 29, 166  
 Dougherty Island, 85, 179  
 Driftwood, 124-125  
 Drygalski, E. von, 29, 68  
 Dufferin, Marquess of, 191  
 D'Urville, D., 25  
 Dutch in Spitsbergen, 9, 203-204

## E

- Earthworms, 114  
 Edinburgh as centre of polar  
   work, 6  
 Edward Land, 29, 83-84, 87-91  
 Egede, H., 193  
 Eider duck, 135  
 Einsamkeit or Lonely Island, 168  
 Ellsworth, L., 19  
 Elton, C. S., 137  
 Enderby Bros., 24, 162  
 Enderby Land, 24  
*Endurance*, 31, 61, 94  
*Erebus and Terror*, 12, 25-26

- Eric the Red, 193, 195  
 Ericksen, M., 17, 106  
 Ermine, 128  
 Eskimo: Caribou, 153-154; cen-  
   sus, 147; characteristics,  
   146; copper or blonde, 146,  
   154; demoralization, 154-  
   156, 220; East Greenland,  
   151-152, 172, 198; future of,  
   156; migration of, 149-154;  
   Norsemen and, 151, 196;  
   origin of, 152; Polar, 151,  
   154; preserves, 171; range  
   of, 146; reindeer breeding,  
   217; whaling, 161-162

## F

- Falkland Islands: dependencies,  
   176-177; penguin slaughter,  
   142; plant life, 124; whaling,  
   162, 165  
 Faroe-Icelandic ridge, 65, 81  
 Filchner, W., 31, 104  
 Fish, Arctic, 135-136  
 Fjaeldmark, 113  
 Flying: Antarctic, 31; Arctic,  
   19, 187-188  
 Fog, 44, 80, 81, 191  
 Föhn winds, 44, 46  
 Fox, Arctic, 129, 145, 205  
*Fram*, 16, 18, 30, 42  
*Français*, 29  
 Franklin, J., 11-12  
 Franz Josef Land: area, 4; dis-  
   covery, 13, 169; ice, 110;  
   lack of economic value, 202;  
   ownership, 169  
 Freezing of sea water, 56-59  
 Freuchen, P., 117  
 Frobisher, M., 9  
 Frostbite, 220  
 Fruits in Arctic, 117

## G

- Gauss*, 29, 98  
 Geer, G. de, 70

George IV Sea, 24  
 Gerlache, A. de, 28  
*Germania* and *Hansa*, 13  
 Giles Land, 109  
*Gjoa*, 12  
 Glacial anticyclone, 42-46  
 Glaciation, recession of, 104-105,  
 109-110  
 Glaciers, alimentation and was-  
 tage, 40, 44-45, 100, 104,  
 108-110  
 Glutton, 128  
 Graah, W. A., 193  
 Graham Land: discovery of, 23;  
 structure, 86-91  
 Grampus, 135, 140  
 Graphite, 199  
 Greek conceptions, 21  
 Greenland: anticyclone, 43-46;  
 area, 4; bishopric, 195;  
 crossings, 108; currents, 72-  
 81; Danes, 197; Denmark's  
 claim, 171-172; discovery,  
 8; eider duck hunting, 135;  
 Eskimo, 147-156; explora-  
 tion, 15, 17, 106; fisheries,  
 136; flora, 117-119; govern-  
 ment, 172-173, 198; hunt-  
 ing, 127, 129, 198; ice-sheet,  
 106-109, 198; minerals,  
 198-199; Norse colonies,  
 47-48, 193-197; Norway's  
 claims, 171-172; observa-  
 tories, 50, 171; seals, 131-  
 133; structure, 198; trade,  
 172, 198; trade routes, 184-  
 185, 198; whaling, 134, 158-  
 162  
 Greenlanders: *see* Greenland and  
 Eskimo  
 Greenland Sea: extent, 64; ice  
 area, 81; sealing, 132; whal-  
 ing, 157-161  
 Gregory, J. W., 86, 87, 88  
 Grenfell, W. T., 155  
 Grönlie, O. T., 110  
 Gypsum, 210

## H

Hafsbøtn, 7  
 Hall, C. F., 12, 14  
 Hanseatic League, 9, 196  
 Hansen, F. C., 197  
 Hare, Arctic, 128  
 Hayes, I. I., 14, 77  
 Healthiness of polar regions, 17,  
 221-222  
 Heard and Macdonald Islands,  
 85, 124, 140, 142, 177  
 Hearne, S., 10  
 Henrietta Island, 111, 168  
 Herbertson, A. J., 2  
 Herjolfsnes, 48, 197  
 Herschel Island, 161  
 Hill, L., 222  
 Hobbs, W. H.: Bruce Land, 29;  
 glacial anticyclones, 43-45  
 Holm, G. F., 193, 195  
 Holtedahl, O., 66  
 Hudson, H., 9  
 Hudson Bay navigation, 183-184  
 Hudson's Bay Co.: Eskimo in-  
 dustries, 155; exploration,  
 10; territories, 170; whaling,  
 162  
 Hudson's Bay Reindeer Co., 217  
 Humidity of air, 40-41  
 Hunting and trapping, 126-134

## I

Ice: change of conditions, 48, 82;  
 North Atlantic trade routes,  
 180-185; patrol, 182; river,  
 78; sheets: — Antarctic, 85,  
 98-106; — Greenland, 106-  
 109, 198; — thickness, 68,  
 71; — Pleistocene, 68, 99;  
*see also* Pack Ice; southern  
 trade routes, 188-191; terms,  
 62-63; tongues, 100-104  
 Ice Barrier: *see* Ross Barrier  
 Icebergs: Antarctic, 97-98, 101,  
 188; Arctic, 78; North  
 Atlantic, 182-183; sudden  
 release of, 77

Ice-breakers, 18, 184, 209-210  
 Iceland moss, 118, 127  
 Insects, Arctic, 136  
 Inversion of temperature, 39, 44,  
     45  
 Iron-ore, meteoric, 199, 201;  
     Spitsbergen, 210  
 Isachsen, G., 16, 18  
 Islands, mythical, 85, 179  
 Isostasy, 66-71, 105

J

Jackman, C., 9  
 Jackson, F. G., 13  
 Jan Mayen, 7, 49, 75, 129, 132,  
     175  
*Jason*, 27  
*Jeannette*, drift of, 15, 16, 74, 75  
 Jenness, D., 146

K

Kane, E. K., 14, 77  
 Kappik, 128  
 Kara Sea, 9, 64, 186-187  
*Karluk*, 74  
 Kellett, H., 169  
 Kerguelen: coal, 124; climate,  
     46, 145; discovery, 22;  
     faunal reserves, 142, 178;  
     French claim, 177, 178; no  
     ice, 105; penguins, 142;  
     plant-life, 124, 145; sealing,  
     140; stock raising, 145;  
     structure, 85; volcanic ac-  
     tivity, 105; whaling, 162  
*King's Mirror*, the, 47, 116,  
     195  
 Knarren, 196, 197  
 Koch, J. P. de, 17, 108  
 Koch, L.: currents, 74; ex-  
     plorations, 17, 106; ice sheet,  
     109; pack-ice, 57, 62  
 Koldeway, K., 13  
 Kolguev, 168, 169, 202  
 Köppen, W., 1  
 Kristensen, L., 27

L

Larsen, C. A., 27, 163, 166  
 Lecointe, G., 28  
 Lemming, 128  
 Level of ocean, changes in, 68-  
     71  
 Limits of polar regions, 1-5  
 Liverpool Island, 179  
 Living off the land, 13, 18, 219  
 Lockwood, J. B., 15  
 Luitpold Coast, 29, 31, 88

M

M'Clintock, L., 12, 17  
 M'Clure, R., 12, 126  
 Macdonald Island: *see* Heard  
     Island  
 Mackenzie, A., 10  
 MacMillan, D. B., 17, 220  
 Macquarie Island: climate, 46;  
     faunal reserve proposed, 142;  
     no ice, 105; ownership, 178;  
     plant-life, 124; sealing, 140;  
     structure, 105  
 Magnetic Pole: north, 11, 12;  
     south, 30  
 Mails to polar lands, 192  
 Mammoth, 137  
 Marion Island, 22, 85, 105, 177  
 Markham, A. H., 14  
 Markham, C. R.: advocacy of  
     Antarctic exploration, 28;  
     warm wind, 44  
 Martonne, E. de, 2  
 Mary Land, 83, 87  
*Maud*, 16, 60  
 Mawson, D.: Antarctic soil, 121;  
     Antarctic structure, 90;  
     Australian claims in Antarc-  
     tic, 178; explorations, 30;  
     faunal reserve proposed, 142;  
     wind velocities, 42  
*Meteor*, 94  
 Meteorological observatories, 49-  
     50  
 Methods of exploration, 13, 17,  
     18, 19, 31-32

Mikkelsen, E., 17, 76, 108  
 Mining camps : Greenland, 199 ;  
     Spitsbergen, 211  
 Mirage, 54-55  
 Moraines, 100, 105  
 Mosquito, 136  
 Mossman, R. C., 96  
 Murray, James, 143  
 Murray, John, 27, 28, 144  
 Muscovy Co., 9, 157, 201  
 Musk-ox, 126, 150-154, 216  
 Mygbugten, 50, 171

## N

Nansen, F. : bottlenose whales, 151 ; continental shelf, 67-69 ; Eskimo, 150 ; *Fram*, 16, 18 ; Greenland crossed, 108 ; ice caps, 71 ; Norse colonies, 195 ; sea ice, 57 ; seals, 131 ; strandflat, 69-71 ; Viking journeys, 7 ; Vinland, 195-196  
 Nares, G. S., 14, 58  
 Narwhal, 134  
 Nathorst, A. G., 17  
 Navigation in pack, 59-60, 209-210  
 Nelson, E. W., 215  
 Nelson, Port, 184  
 Neumayer, G. von, 27, 28, 42  
 New Siberian Islands, 66, 127, 111, 168 ; ivory, 137  
 Nicholas Land, 17, 78, 111, 187  
 Nimrod group, 85, 179  
 Nordenskiöld, A. E., 13, 14, 127, 186  
 Nordenskiöld, O., 29, 98  
 Norge, 19, 168  
 Nörlund, P., 47-48, 196-197  
 Norse colonies in Greenland, 47-48, 193-197  
 Norse voyages, 7, 193, 195  
 Norsemen and Eskimo, 151, 196-197  
 North-East passage, 8, 13, 185-187

Northern Land : *see* Nicholas Land  
 North Water, 77, 158  
 North-West passage, 8-13  
 North Western Co., 10  
 Norway and Spitsbergen, 173-174  
 Norwegian Sea : *see* Greenland Sea  
 Norwegian trappers, 128, 133, 134, 205  
 Novaya Zemlya : discovery, 9 ; flora, 118 ; ice, 110 ; meteorological stations, 50 ; minerals, 202 ; ownership, 168-169 ; Samoyedes, 201-202 ; structure, 201 ; strandflat, 69, 71

## O

Oates Land, 30, 84, 97  
 Oesterbygd, 193-197  
 Okhotsk Sea, 185  
 Ortelius, map of, 9  
 Ostensfeld, C. H., 118  
 Ottar, 7  
 Ovibos : *see* Musk-ox

## P

Pack-ice : Antarctic, 96-98 ; Arctic, 74-82 ; growth and thickness, 57-62 ; *see also* Ice  
 Palæocrystic ice, 58, 63  
 Palmer, N. B., 23  
 Parry, W. E., 11, 14  
 Pasture in Arctic, 112, 116, 213-217  
 Payer, J., 13, 169  
 Peary Land, 106  
 Peary, R. F., 15-17, 59, 65, 169  
 Peat, 118, 123  
 Penck, A., 68  
 Penguins, 141-142  
 Pet, A., 9  
 Petermann, A., 14  
 Petterssen, O., 48  
 Phipps, J. C., 11  
 Pilestraedet, 72

- Plant life: Antarctic conditions, 120-121; Arctic conditions, 112-116
- Plants of economic value, 116-118
- Pleistocene Ice Age, 110, 111, 118
- Polar bear, 129-130; — cattle; *see* Musk-ox; — continent, 65; — Eskimo, 151, 154, 201; — front, 46; — sea, open, 74, 77
- Pole: auroral frequency, 54; inaccessibility, 19, 60; magnetic, north, 11, 12; magnetic, south, 30; north, 16, 170; south, 30, 177
- Pollog, C. H., 40
- Pourquoi Pas?*, 29
- Powell, G., 23
- Powell group, 86
- Precipitation, 40-41, 44; on ice sheets, 44-45, 109
- Pressure, atmospheric, 41-46
- Priestley, R. E., 87, 92, 99, 101
- Ptarmigan, 119, 135
- Pytheas, 7
- Q
- Quervain, A. de, 45, 108, 109
- R
- Rae, J., 11, 12, 18, 219
- Ragnvald Jarl*, 75
- Rasmussen, K., 17, 147, 149, 151, 153
- Red snow, 123
- Refraction, 55
- Reindeer, 126-128; breeding, 145, 213-217; Eskimo and, 149-154; moss, 118, 127; protection of, 174
- Richardson, J., 11
- Rink, H.: föhn winds, 46; Eskimo, 117, 153, 219
- River ice, 78
- Ross Barrier, 26, 102-103; — deep, 26, 94; — dependency, 177
- Ross Sea: currents and ice, 97; extent, 87; whaling, 166
- Ross, J., 11, 154
- Ross, J. C., 11, 25
- Rotifers, 123, 143
- Royal Company Island, 85, 179
- Russian Arctic sovereignty, 168-169; — ice-breakers, 17, 18
- Russians: Novaya Zemlya, 201; Spitsbergen, 204, 218
- S
- Sabrina Land, 24
- Salinity of sea-ice, 62
- Samoyedes, 201-202
- Savsatt, 134
- Schöner's globe, 21
- Scoresby, W., 11, 122
- Scotia, 21, 29, 49, 61, 94, 96, 98, 159, 182
- Scotia ridge, 94
- Scott, R. F., 29, 30, 43, 222
- Scott Polar Research Institute, 6
- Scottish Oceanographical Laboratory, 6
- Scurvy, 117, 204, 218-219
- Sealers' discoveries, 23-24
- Seals: Antarctic, 138-140; Arctic, 130-133; Eskimo and, 149-154
- Shackleton, E. H., 31, 36
- Sharks, 136
- Siberian coast, ice on, 78, 187
- Sikûssaq, 62
- Simpson, G. C., 45
- Smeerenburg, 203
- Smith, B. Leigh, 13, 219
- Smith, W., 23
- Snowblindness, 220
- Soapstone, 199
- Soil, 113-114, 120, 121
- South Georgia: British possession, 175-176; climate, 4; discovery, 23; Exploration Co., 144; glaciers, 105-106; mails, 192; observatories, 49; plant-life, 124; sealing, 139-140; stock-raising, 144; structure, 86-87; whaling, 163-165

- South Orkneys: claims to, 175;  
discovery, 23; observatory,  
49, 175; temperatures, 34,  
35; structure, 86; whaling,  
165
- South Sandwich group: dis-  
covery, 24; sealing, 139-140;  
structure, 85, 86
- South Shetlands: discovery, 23;  
sealing, 139-140; whaling,  
165
- Southern Antilles, 86-91, 94
- Southern Cross*, 28
- Southern Ocean: currents, 93-  
98; ice, 96-98, 188-191;  
limits, 93
- Sovereignty of empty lands, 167
- Spitsbergen: area, 4; coal min-  
ing, 206-211; discovery, 7,  
9, 13; fisheries, 136; flora,  
116, 118, 119; fox, destruc-  
tion of, 128; game laws,  
174; gypsum, 210; ice on  
coasts, 80, 185, 209; ice  
sheets, 109; iron, 210;  
mails, 192; Norway and,  
173-174; Norwegian trap-  
pers, 205; plants, protection  
of, 174; reindeer, 127-128;  
Russian trappers, 204; soil,  
114; structure, 205-206;  
trapping, 204-205; walrus,  
133; whaling, 158, 160, 203;  
white whales, 134
- Steensby, H. P., 152, 153
- Stefansson, V.: Eskimo, 117, 147,  
149, 152, 155; explorations,  
16, 17, 18; reindeer and  
musk-ox, 126, 212-217; pole  
of inaccessibility, 19, 60;  
Wrangel Island, 168-169
- Storis, 75, 76
- Strandflat, 69-71
- Sub-Antarctic Islands: climate,  
46-47; structure, 85-87;  
vegetation, 123-124; *see also*  
South Georgia, Kerguelen,  
etc.
- Sun's path, 1; — refraction, 55;  
— temperature, 35, 113
- Supan, A., 1
- Svalbard: *see* Spitsbergen
- Sverdrup, H. U., 39, 65
- Sverdrup, O., 16, 17, 18
- T
- Taimir and Vaigach*, 13, 17
- Taylor, Griffith, 109
- Tegetthof*, 13
- Temperatures, polar, 33-40
- Terra Nova*, 30
- Théel, H., 144
- Thompson Island, 85, 179
- Thule, 172
- Tourist traffic, polar, 191-192
- Treeless areas, 3-4
- Trinity Land, 23
- Tyrrell, G. W., 110
- U
- Unicorn, 134
- V
- Vaigach, 202
- Valdivia*, 94
- Vega*, 13, 17, 186
- Vesterbygd, 193-197
- Vestis, 96
- Victoria Land: discovery, 26;  
structure, 84, 86-91
- Viking discoveries, 7, 8
- Vilkitski, B. A., 13, 168
- Villiers, A. J., 140
- Vinci, L. da, globe, 21
- Vinland, story of, 195-196
- Volcanic activity: Antarctic, 85-  
87, 105; Arctic, 67
- W
- Walrus, 133
- Warming, E., 113
- Water temperatures, 56-57, 98

- Weddell Barrier, 32, 104  
 Weddell, J., 23, 138, 140  
 Weddell Sea: discovery, 24 ;  
     currents and ice, 61, 97  
 Wegener's theory, 67, 91-92  
 Wellman, W., 19  
 Werenskiöld, W., 117  
 West Water, 77  
 Weyprecht, C., 13  
 Whale: bottlenose, 161 ; hump-  
     back, 161, 165 ; killer, 135,  
     140 ; products, 157, 159, 165 ;  
     right, 157-159, 162 ; rorqual,  
     160, 165, 166 ; sperm, 163 ;  
     white, 134  
 Whaling: Alaskan, 160-161 ;  
     Antarctic, 162-166 ; Arctic,  
     157-162 ; Basque, 157 ;  
     Scottish, 158, 159, 161  
 White Sea ice, 185  
 Wiggins, J., 186  
 Wilhelm Barrier: *see* Weddell  
     Barrier  
 Wilhelm Land, 29, 83, 84  
 Wilkes, C., 25  
 Wilkes Land, 25, 30, 84, 88  
*William Scoresby*, 166  
 Willoughby, H., 9  
 Wireless stations, 49, 50, 169, 187  
 Wisting, O., 16, 60  
 Wolf, Arctic, 128-129  
 Wordie, J. M., 97, 99, 110  
 Wrangel Island: air station, 188 ;  
     ice, 78, 111 ; ownership, 168-  
     169 ; settlement, 169, 202  
 Wright, C. S., 92, 99, 101, 102  
 Wulff, Th., 113  
 Wyville Thompson ridge, 65, 81
- Y
- Yamal: routes across, 186 ; wire-  
     less station, 187  
 Yenisei trade route, 186
- Z
- Zarya*, 17  
 Zeno, map of, 9

Printed in Great Britain by  
Butler & Tanner Ltd.,  
Frome and London

**METHUEN'S GENERAL LITERATURE**



## A SELECTION OF MESSRS. METHUEN'S PUBLICATIONS

This Catalogue contains only a selection of the more important books published by Messrs. Methuen. A complete catalogue of their publications may be obtained on application.

### PART I. GENERAL LITERATURE

**Armstrong (Anthony) ("A.A.")**

WARRIORS AT EASE. WARRIORS STILL AT EASE. PERCIVAL AND I. HOW TO DO IT. *Each 3s. 6d. net.*

**Ashby (Thomas).**

SOME ITALIAN SCENES AND FESTIVALS. With 24 Illustrations. *Crown 8vo. 7s. 6d. net.*

**Bain (F. W.)**

A DIGIT OF THE MOON. THE DESCENT OF THE SUN. A HEIFER OF THE DAWN. IN THE GREAT GOD'S HAIR. A DRAUGHT OF THE BLUE. AN ESSENCE OF THE DUSK. AN INCARNATION OF THE SNOW. A MINE OF FAULTS. THE ASHES OF A GOD. BUBBLES OF THE FOAM. A SYRUP OF THE BEES. THE LIVERY OF EVE. THE SUBSTANCE OF A DREAM. *All Fcap. 8vo. 5s. net. AN ECHO OF THE SPHERES. Wide Demy 8vo. 10s. 6d. net.*

**Balfour (Sir Graham)**

THE LIFE OF ROBERT LOUIS STEVENSON. *Twentieth Edition. In one Volume. Cr. 8vo. Buckram, 7s. 6d. net.*

**Barker (Ernest)**

NATIONAL CHARACTER. *Demy 8vo. 10s. 6d. net.* GREEK POLITICAL THEORY: Plato and his Predecessors. *Second Edition. Demy 8vo. 14s. net.*

**Belloc (Hilaire)**

PARIS. THE PYRENEES. *Each 8s. 6d. net.* ON NOTHING. HILLS AND THE SEA. ON SOMETHING. THIS AND THAT AND

THE OTHER. ON. *Each 6s. net.* FIRST AND LAST. ON EVERYTHING. ON ANYTHING. EMMANUEL BURDEN. *Each 3s. 6d. net.* MARIE ANTOINETTE. 18s. *net.* A HISTORY OF ENGLAND. In 5 vols. Vols. I, II, III and IV. 15s. *net each.* HILLS AND THE SEA. Illustrated in Colour by Donald Maxwell. 15s. *net.*

**Birmingham (George A.)**

A WAYFARER IN HUNGARY. Illustrated. 8s. 6d. *net.* SPILLIKINS. SHIPS AND SEALING-WAX. Two Books of Essays. *Each 3s. 6d. net.*

**Budge (Sir E. A. Wallis)**

A HISTORY OF ETHIOPIA: NUBIA AND ABYSSINIA. Illustrated. In 2 vols. £3 13s. 6d. *net.*

**Chandler (Arthur), D.D.**

ARA CÆLI. 5s. *net.* FAITH AND EXPERIENCE. 5s. *net.* THE CULT OF THE PASSING MOMENT. 6s. *net.* THE ENGLISH CHURCH AND REUNION. 5s. *net.* SCALA MUNDI. 4s. 6d. *net.*

**Chesterton (G. K.)**

THE BALLAD OF THE WHITE HORSE. 3s. 6d. *net.* Also illustrated by ROBERT AUSTIN. 12s. 6d. *net.* CHARLES DICKENS. 3s. 6d. *net.* GENERALLY SPEAKING. ALL THINGS CONSIDERED. TREMENDOUS TRIFLES. FANCIES VERSUS FADS. ALARMS AND DISCURSIONS. A MISCELLANY OF MEN. THE USES OF DIVERSITY. THE OUTLINE OF SANITY. *Each Fcap. 8vo. 6s. net.* A GLEAM-

ING COHORT. *Fcap.* 8vo. 2s. 6d. net.  
WINE, WATER, AND SONG. *Fcap.* 8vo.  
1s. 6d. net.

**Clutton-Brock (A.)**

WHAT IS THE KINGDOM OF HEAVEN?  
ESSAYS ON ART. SHAKESPEARE'S HAM-  
LET. *Each* 5s. net. ESSAYS ON BOOKS.  
MORE ESSAYS ON BOOKS. ESSAYS ON  
LIFE. ESSAYS ON RELIGION. ESSAYS ON  
LITERATURE AND LIFE. MORE ESSAYS  
ON RELIGION. *Each* 6s. net. SHELLEY,  
THE MAN AND THE POET. 7s. 6d. net.

**Cottenham (The Earl of)**

MOTORING WITHOUT FEARS. Illus-  
trated. 2s. 6d. net. MOTORING TO-  
DAY AND TO-MORROW. Illustrated by  
A. E. HORNE 5s. net.

**Crawley (Ernest)**

THE MYSTIC ROSE. Revised and  
Enlarged by THEODORE BESTERMAN.  
Two Vols. *Demy* 8vo. £1 10s. net.  
STUDIES OF SAVAGES AND SEX. Edited  
by THEODORE BESTERMAN. *Demy* 8vo.  
10s. 6d. net.

**Dolls' House (The Queen's)**

THE BOOK OF THE QUEEN'S DOLLS'  
HOUSE. Vol. I. THE HOUSE, Edited  
by A. C. BENSON, C.V.O., and Sir  
LAWRENCE WEAVER, K.B.E. Vol. II.  
THE LIBRARY, Edited by E. V. LUCAS.  
Profusely Illustrated. A Limited Edi-  
tion. *Crown* 4to. £6 6s. net.  
EVERYBODY'S BOOK OF THE QUEEN'S  
DOLLS' HOUSE. An abridged edition  
of the above. Illustrated. *Crown* 4to.  
5s. net.

**Dugdale (E. T. S.)**

GERMAN DIPLOMATIC DOCUMENTS,  
1871-1914. Selected from the Docu-  
ments published by the German For-  
eign Office. In 4 vols. Vol. I, 1871-  
90. Vol. II, 1891-8. *Demy* 8vo.  
*Each* £1 5s. net.

**Edwardes (Tickner)**

THE LORE OF THE HONEYBEE. *Thir-*  
*teenth Edition.* 7s. 6d. net. BEEKEEPING  
FOR ALL. 3s. 6d. net. THE BEE-  
MASTER OF WARRILOW. *Third Edition.*  
7s. 6d. net. All illustrated. BEE-  
KEEPING DO'S AND DON'TS. 2s. 6d. net.

**Einstein (Albert)**

RELATIVITY: THE SPECIAL AND GEN-  
ERAL THEORY. 5s. net. SIDELIGHTS  
ON RELATIVITY. 3s. 6d. net. THE  
MEANING OF RELATIVITY. 5s. net.  
THE BROWNIAN MOVEMENT. 5s. net.  
*Write for Complete List of books on*  
*Relativity.*

**Ermann (Adolph)**

THE LITERATURE OF THE ANCIENT  
EGYPTIANS: POEMS, NARRATIVES, AND  
MANUALS OF INSTRUCTION FROM THE  
THIRD AND SECOND MILLENNIA B.C.  
Translated by Dr. A. M. BLACKMAN.  
*Demy* 8vo. £1 1s. net.

**Fouquet (Jean)**

THE LIFE OF CHRIST AND HIS MOTHER.  
From Fouquet's "Book of Hours."  
Edited by FLORENCE HEYWOOD, B.A.  
With 24 Plates in Colours. In a box.  
*Crown* 4to. £3 3s. net.

**Fyleman (Rose)**

FAIRIES AND CHIMNEYS. THE FAIRY  
GREEN. THE FAIRY FLUTE. THE  
RAINBOW CAT. EIGHT LITTLE PLAYS  
FOR CHILDREN. FORTY GOOD-NIGHT  
TALES. FAIRIES AND FRIENDS. THE  
ADVENTURE CLUB. FORTY GOOD-MORN-  
ING TALES. SEVEN LITTLE PLAYS FOR  
CHILDREN. *Each* 3s. 6d. net. OLD-  
FASHIONED GIRLS. Illustrated by  
ETHEL EVERETT. 7s. 6d. net. A SMALL  
CRUISE. 4s. 6d. net. THE ROSE FYLEMAN  
FAIRY BOOK. Illustrated by HILDA  
MILLER. 10s. 6d. net. A GARLAND OF  
ROSE'S: COLLECTED POEMS. Illustrated  
by RENÉ BULL. 8s. 6d. net. LETTY.  
Illustrated. 6s. net. A PRINCESS COMES  
TO OUR TOWN. Illustrated. 5s. net. A  
LITTLE CHRISTMAS BOOK. Illustrated.  
2s. net.

**Gibbon (Edward)**

THE DECLINE AND FALL OF THE ROMAN  
EMPIRE. With Notes, Appendixes, and  
Maps, by J. B. BURY. Illustrated.  
Seven volumes. *Demy* 8vo. 15s. net  
each volume. Also, unillustrated.  
*Crown* 8vo. 7s. 6d. net each volume.

**Glover (T. R.)**

THE CONFLICT OF RELIGIONS IN THE  
EARLY ROMAN EMPIRE. POETS AND  
PURITANS. VIRGIL. *Each* 10s. 6d. net.  
FROM PERICLES TO PHILIP. 12s. 6d. net.

**Graham (Harry)**

THE WORLD WE LAUGH IN: More  
Departmental Ditties. Illustrated by  
"FISH." *Seventh Edition.* 5s. net.  
STRAINED RELATIONS. Illustrated by  
H. STUART MENZIES and HENDY. 6s. net.  
THE WORLD'S WORKERS. Illustrated  
by "FOUGASSE." 5s. net.

**Grahame (Kenneth)**

THE WIND IN THE WILLOWS. *Nine-*  
*teenth Edition.* *Crown* 8vo. 7s. 6d.  
net. Also, illustrated by WYNDHAM

PAYNE. *Small 4to.* 7s. 6d. net. Also unillustrated. *Fcap.* 8vo. 3s. 6d. net.

**Hadfield (J. A.)**

PSYCHOLOGY AND MORALS. *Seventh Edition.* Crown 8vo. 6s. net.

**Hall (H. R.)**

THE ANCIENT HISTORY OF THE NEAR EAST. *Seventh Edition Revised.* Demy 8vo. £1 1s. net. THE CIVILIZATION OF GREECE IN THE BRONZE AGE. Illustrated. *Wide Royal* 8vo. £1 10s. net. A SEASON'S WORK AT UR OF THE CHALDEES. Demy 8vo. 15s. net.

**Herbert (A. P.)**

HONEYBUBBLE & CO. 6s. net. MISLEADING CASES IN THE COMMON LAW. With an Introduction by LORD HEWART. 5s. net. THE BOMBER GIPSY. 3s. 6d. net. LIGHT ARTICLES ONLY. Illustrated. 6s. net. THE WHEREFORE AND THE WHY. "TINKER, TAILOR . . ." Each illustrated. 3s. 6d. net. THE SECRET BATTLE. 3s. 6d. net.

**Hind (A. M.)**

A CATALOGUE OF REMBRANDT'S ETCHINGS. Two Vols. Profusely Illustrated. *Wide Royal* 8vo. £1 15s. net.

**Holdsworth (W. S.)**

A HISTORY OF ENGLISH LAW. Nine Volumes. Demy 8vo. £1 5s. net each.

**Hudson (W. H.)**

A SHEPHERD'S LIFE. Illustrated. Demy 8vo. 10s. 6d. net. Also, unillustrated. *Fcap.* 8vo. 3s. 6d. net.

**Hutton (Edward)**

CITIES OF SICILY. Illustrated. 10s. 6d. net. MILAN AND LOMBARDY. THE CITIES OF ROMAGNA AND THE MARCHES. SIENA AND SOUTHERN TUSCANY. VENICE AND VENETIA. THE CITIES OF SPAIN. NAPLES AND SOUTHERN ITALY. Illustrated. Each, 8s. 6d. net. A WAYFARER IN UNKNOWN TUSCANY. THE CITIES OF UMBRIA. COUNTRY WALKS ABOUT FLORENCE. ROME. FLORENCE AND NORTHERN TUSCANY. Each illustrated. 7s. 6d. net.

Inge (W. R.), D.D., Dean of St. Paul's. CHRISTIAN MYSTICISM. (The Bampton Lectures of 1899.) *Sixth Edition.* Crown 8vo. 7s. 6d. net.

**Kipling (Rudyard)**

BARRACK-ROOM BALLADS. 246th Thousand.

THE SEVEN SEAS. 180th Thousand.

THE FIVE NATIONS. 143rd Thousand. DEPARTMENTAL DITTIES. 111th Thousand.

THE YEARS BETWEEN. 95th Thousand. Four Editions of these famous volumes of poems are now published, viz.:—Crown 8vo. Buckram, 7s. 6d. net. *Fcap.* 8vo. Cloth, 6s. net. Leather, 7s. 6d. net. Service Edition. Two volumes each book. *Square Fcap.* 8vo. 3s. net each volume.

A KIPLING ANTHOLOGY—Verse. *Fcap.* 8vo. Cloth, 6s. net and 3s. 6d. net. Leather, 7s. 6d. net. TWENTY POEMS FROM RUDYARD KIPLING. 458th Thousand. *Fcap.* 8vo. 1s. net. A CHOICE OF SONGS. *Second Edition.* *Fcap.* 8vo. 2s. net.

**Lamb (Charles and Mary)**

THE COMPLETE WORKS. Edited by E. V. LUCAS. A New and Revised Edition in Six Volumes. With Frontispieces. *Fcap.* 8vo. 6s. net each.

The volumes are: I. MISCELLANEOUS PROSE. II. ELIA AND THE LAST ESSAYS OF ELIA. III. BOOKS FOR CHILDREN. IV. PLAYS AND POEMS. V. and VI. LETTERS.

SELECTED LETTERS. Chosen and Edited by G. T. CLAPTON. *Fcap.* 8vo. 3s. 6d. net. THE CHARLES LAMB DAY BOOK. Compiled by E. V. LUCAS. *Fcap.* 8vo. 6s. net.

**Lanckester (Sir Ray)**

SCIENCE FROM AN EASY CHAIR. SCIENCE FROM AN EASY CHAIR: Second Series. DIVERSIONS OF A NATURALIST. GREAT AND SMALL THINGS. Illustrated. Crown 8vo. 7s. 6d. net. SECRETS OF EARTH AND SEA. Illustrated. Crown 8vo. 8s. 6d. net.

**Lodge (Sir Oliver)**

MAN AND THE UNIVERSE (*Twentieth Edition*). 7s. 6d. net and 3s. 6d. net. THE SURVIVAL OF MAN (*Seventh Edition*). 7s. 6d. net. RAYMOND. (*Thirteenth Edition*). 10s. 6d. net. RAYMOND REVISED. 6s. net. MODERN PROBLEMS. 3s. 6d. net. THE SUBSTANCE OF FAITH (*Fifteenth Edition*). 2s. net. RELATIVITY (*Fourth Edition*). 1s. net.

**Lucas (E. V.)**

THE LIFE OF CHARLES LAMB. 2 Vols. £1 1s. net. EDWIN AUSTIN ABBEY, R.A. 2 Vols. £6 6s. net. THE COLVINS AND THEIR FRIENDS. £1 1s. net. VERMEER THE MAGICAL. 5s. net. A WANDERER IN ROME. A WANDERER

IN HOLLAND. A WANDERER IN LONDON. LONDON REVISITED (Revised). A WANDERER IN PARIS. A WANDERER IN FLORENCE. A WANDERER IN VENICE. *Each* 10s. 6d. *net*. A WANDERER AMONG PICTURES. 8s. 6d. *net*. E. V. LUCAS'S LONDON. £1 *net*. INTRODUCING LONDON. INTRODUCING PARIS. *Each* 2s. 6d. *net*. THE OPEN ROAD. 6s. *net*. Also, illustrated by CLAUDE A. SHEPPERSON, A.R.W.S. 10s. 6d. *net*. Also, India Paper. *Leather*, 7s. 6d. *net*. THE JOY OF LIFE. 6s. *net*. *Leather Edition*. 7s. 6d. *net*. Also India Paper. *Leather*. 7s. 6d. *net*. FIRESIDE AND SUNSHINE. CHARACTER AND COMEDY. *Each* 6s. *net*. THE GENTLEST ART. 6s. 6d. *net*. AND THE SECOND POST. 6s. *net*. Also, together in one volume. 7s. 6d. *net*. HER INFINITE VARIETY. GOOD COMPANY. ONE DAY AND ANOTHER. OLD LAMPS FOR NEW. LOITERER'S HARVEST. CLOUD AND SILVER. A BOSWELL OF BAGHDAD. "TWIXT EAGLE AND DOVE. THE PHANTOM JOURNAL. GIVING AND RECEIVING. LUCK OF THE YEAR. ENCOUNTERS AND DIVERSIONS. ZIGZAGS IN FRANCE. EVENTS AND EMBROIDERIES. 365 DAYS (AND ONE MORE). A FRONDED ISLE. A ROVER I WOULD BE. *Each* 6s. *net*. URBANITIES. Illustrated by G. L. STAMPA. 5s. *net*. YOU KNOW WHAT PEOPLE ARE. Illustrated by GEORGE MORROW. 5s. *net*. THE SAME STAR: A Comedy in Three Acts. 3s. 6d. *net*. LITTLE BOOKS ON GREAT MASTERS. *Each* 5s. *net*. ROVING EAST AND ROVING WEST. 5s. *net*. PLAYTIME & COMPANY. 7s. 6d. *net*. *Mr. Punch's* COUNTY SONGS. Illustrated by E. H. SHEPARD. 10s. 6d. *net*. "THE MORE I SEE OF MEN . . ." OUT OF A CLEAR SKY. *Each* 3s. 6d. *net*. See also *Dolls' House* (The Queen's) and *Lamb* (Charles).

**Lucas (E. V.) and Finck (Herman)**  
TWELVE SONGS FROM "PLAYTIME & COMPANY." Words by E. V. LUCAS. Music by HERMAN FINCK. *Royal* 4to. 7s. 6d. *net*.

**Lynd (Robert)**  
THE GREEN MAN. OLD FRIENDS IN FICTION. THE GOLDFISH. THE PLEASURES OF IGNORANCE. *Each* 5s. *net*. THE LITTLE ANGEL. THE BLUE LION. THE PEAL OF BELLS. THE MONEY BOX. THE ORANGE TREE. *Each* 3s. 6d. *net*.

**McDougall (William)**  
AN INTRODUCTION TO SOCIAL PSYCHO-

LOGY (*Twenty-first Edition*). 10s. 6d. *net*. NATIONAL WELFARE AND NATIONAL DECAY. 6s. *net*. AN OUTLINE OF PSYCHOLOGY (*Fourth Edition*). 10s. 6d. *net*. AN OUTLINE OF ABNORMAL PSYCHOLOGY. 15s. *net*. BODY AND MIND (*Sixth Edition*). 12s. 6d. *net*. CHARACTER AND THE CONDUCT OF LIFE (*Third Edition*). 10s. 6d. *net*. MODERN MATERIALISM AND EMERGENT EVOLUTION. 7s. 6d. *net*. ETHICS AND SOME MODERN WORLD PROBLEMS (*Second Edition*). 7s. 6d. *net*.

**Mackenzie (W. Mackay)**

THE MEDIEVAL CASTLE IN SCOTLAND. (The Rhind Lectures on Archæology. 1925-6.) Illustrated. *Demy* 8vo. 15s. *net*.

**Mallet (Sir C. E.)**

A HISTORY OF THE UNIVERSITY OF OXFORD. In 3 vols. Illustrated. *Demy* 8vo. *Each* £1 1s. *net*.

**Maeterlinck (Maurice)**

THE BLUE BIRD. 6s. *net*. Also, illustrated by F. CAYLEY ROBINSON. 10s. 6d. *net*. DEATH. 3s. 6d. *net*. OUR ETERNITY. 6s. *net*. THE UNKNOWN GUEST. 6s. *net*. POEMS. 5s. *net*. THE WRACK OF THE STORM. 6s. *net*. THE MIRACLE OF ST. ANTHONY. 3s. 6d. *net*. THE BURGOMASTER OF STILEMONDE. 5s. *net*. THE BETROTHAL. 6s. *net*. MOUNTAIN PATHS. 6s. *net*. THE STORY OF TYLTYL. £1 1s. *net*. THE GREAT SECRET. 7s. 6d. *net*. THE CLOUD THAT LIFTED and THE POWER OF THE DEAD. 7s. 6d. *net*. MARY MAGDALENE. 2s. *net*.

**Masefield (John)**

ON THE SPANISH MAIN. 8s. 6d. *net*. A SAILOR'S GARLAND. 6s. *net* and 3s. 6d. *net*. SEA LIFE IN NELSON'S TIME. 5s. *net*.

**Methuen (Sir A.)**

AN ANTHOLOGY OF MODERN VERSE 147th *Thousand*. SHAKESPEARE TO HARDY: An Anthology of English Lyrics. 19th *Thousand*. *Each* *Fcap*. 8vo. *Cloth*, 6s. *net*. *Leather*, 7s. 6d. *net*.

**Milne (A. A.)**

TOAD OF TOAD HALL. 5s. *net*. NOT THAT IT MATTERS. IF I MAY. THE SUNNY SIDE. THE RED HOUSE MYSTERY. ONCE A WEEK. THE HOLIDAY ROUND. THE DAY'S PLAY. *Each* 3s. 6d. *net*. WHEN WE WERE VERY YOUNG. *Eighteenth Edition*. 189th *Thousand*. WINNIE-THE-POOH. *Seventh Edition*. 96th *Thousand*. NOW WE ARE SIX. *Fourth Edition*. 109th *Thou-*

- sand. THE HOUSE AT POOH CORNER. Second Edition. 86th Thousand. Each illustrated by E. H. SHEPARD. 7s. 6d. net. Leather, 10s. 6d. net. FOR THE LUNCHEON INTERVAL. 1s. 6d. net.*
- Milne (A. A.) and Fraser-Simson (H.)**  
FOURTEEN SONGS FROM "WHEN WE WERE VERY YOUNG." *Twelfth Edition. 7s. 6d. net.* TEDDY BEAR AND OTHER SONGS FROM "WHEN WE WERE VERY YOUNG." *7s. 6d. net.* THE KING'S BREAKFAST. *Third Edition. 3s. 6d. net.* SONGS FROM "NOW WE ARE SIX." *Second Edition. 7s. 6d. net.* MORE SONGS FROM "NOW WE ARE SIX." *7s. 6d. net.* Words by A. A. MILNE. Music by H. FRASER-SIMSON. Decorations by E. H. SHEPARD.
- Montague (C. E.)**  
DRAMATIC VALUES. *Cr. 8vo. 7s. 6d. net.*
- Morton (H. V.)**  
THE HEART OF LONDON. *3s. 6d. net.* (Also illustrated, *7s. 6d. net.*) THE SPELL OF LONDON. THE NIGHTS OF LONDON. *Each 3s. 6d. net.* THE LONDON YEAR. IN SEARCH OF ENGLAND. THE CALL OF ENGLAND. IN SEARCH OF SCOTLAND. *Each illustrated. 7s. 6d. net.*
- Oman (Sir Charles)**  
A HISTORY OF THE ART OF WAR IN THE MIDDLE AGES, A.D. 378-1485. 2 Vols. Illustrated. *Demy 8vo. £1 16s. net.* STUDIES IN THE NAPOLEONIC WARS. *Crown 8vo. 8s. 6d. net.*
- Oxenham (John)**  
BEES IN AMBER. *Small Pott 8vo. 2s. net.* ALL'S WELL. THE KING'S HIGHWAY. THE VISION SPLENDID. THE FIERY CROSS. HIGH ALTARS. HEARTS COURAGEOUS. ALL CLEAR! *Each Small Pott 8vo. Paper, 1s. 3d. net. Cloth, 2s. net.* WINDS OF THE DAWN. *2s. net.*
- Perry (W. J.)**  
THE ORIGIN OF MAGIC AND RELIGION. THE GROWTH OF CIVILIZATION. *Each 6s. net.* THE CHILDREN OF THE SUN. *£1 1s. net.*
- Petrie (Sir Flinders)**  
A HISTORY OF EGYPT. In 6 Volumes. Vol. I. FROM THE 1ST TO THE XVIth DYNASTY. *11th Edition, Revised. 12s. net.* Vol. II. THE XVIIth AND XVIIIth DYNASTIES. *7th Edition, Revised. 9s. net.* Vol. III. XIXth TO XXXth DYNASTIES. *3rd Edition. 12s. net.* Vol. IV. EGYPT UNDER THE PTOLEMAIC DYNASTY. By EDWYN BEVAN. *15s. net.* Vol. V. EGYPT UNDER ROMAN RULE. By J. G. MILNE. *3rd Edition, Revised. 12s. net.* Vol. VI. EGYPT IN THE MIDDLE AGES. By STANLEY LANE POOLE. *4th Edition. 10s. net.*
- Ponsonby (Arthur), M.P.**  
ENGLISH DIARIES. *£1 1s. net.* MORE ENGLISH DIARIES. *12s. 6d. net.* SCOTTISH AND IRISH DIARIES. *10s. 6d. net.*
- Raleigh (Sir Walter)**  
THE LETTERS OF SIR WALTER RALEIGH. Edited by LADY RALEIGH. Two Vols. Illustrated. *Second Edition. Demy 8vo. 18s. net.* SELECTED LETTERS. Edited by LADY RALEIGH. *7s. 6d. net.*
- Smith (C. Fox)**  
SAILOR TOWN DAYS. SEA SONGS AND BALLADS. A BOOK OF FAMOUS SHIPS. SHIP ALLEY. ANCIENT MARINERS. *Each, illustrated, 6s. net.* FULL SAIL. Illustrated. *5s. net.* TALES OF THE CLIPPER SHIPS. A SEA CHEST. *Each 5s. net.* THE RETURN OF THE "CUTTY SARK." Illustrated. *3s. 6d. net.* A BOOK OF SHANTIES. *6s. net.*
- Stevenson (R. L.)**  
THE LETTERS. Edited by Sir SIDNEY COLVIN. 4 Vols. *Fcap. 8vo. Each 6s. net.*
- Surtees (R. S.)**  
HANDLEY CROSS. MR. SPONGE'S SPORTING TOUR. ASK MAMMA. MR. FACEY ROMFORD'S HOUNDS. PLAIN OR RINGLETS? HILLINGDON HALL. *Each illustrated, 7s. 6d. net.* JORROCK'S JAUNTS AND JOLLITIES. HAWBUCK GRANGE. *Each, illustrated, 6s. net.*
- Taylor (A. E.)**  
PLATO: THE MAN AND HIS WORK. *Demy 8vo. £1 1s. net.* PLATO: TIMÆUS AND CRITIÆUS. *Crown 8vo. 8s. 6d. net.* ELEMENTS OF METAPHYSICS. *Demy 8vo. 12s. 6d. net.*
- Tilden (William T.)**  
THE ART OF LAWN TENNIS. SINGLES AND DOUBLES. *Each, illustrated, 6s. net.* THE COMMON SENSE OF LAWN TENNIS. MATCH PLAY AND THE SPIN OF THE BALL. *Illustrated. 5s. net.*
- Tileston (Mary W.)**  
DAILY STRENGTH FOR DAILY NEEDS. *32nd Edition. 3s. 6d. net.* India Paper. *Leather, 6s. net.*
- Trapp (Oswald Graf)**  
THE ARMOURY OF THE CASTLE OF CHURBURG. Translated by J. G. MANN. Richly illustrated. *Royal 4to. Limited to 400 copies. £4 14s. 6d. net.*

**Underhill (Evelyn)**

MYSTICISM (*Eleventh Edition*). 15s. net.  
 THE LIFE OF THE SPIRIT AND THE LIFE  
 OF TO-DAY (*Sixth Edition*). 7s. 6d.  
 net. MAN AND THE SUPERNATURAL.  
 7s. 6d. net. CONCERNING THE INNER  
 LIFE (*Fourth Edition*). 2s. net.

**Vardon (Harry)**

HOW TO PLAY GOLF. Illustrated.  
 19th Edition. Crown 8vo. 5s. net.

**Wand (J. W. C.).**

THE DEVELOPMENT OF SACRAMENTAL-  
 ISM. Fcap. 8vo. 6s. net. A HISTORY  
 OF THE MODERN CHURCH. Crown 8vo.  
 7s. 6d. net.

**Wilde (Oscar)**

THE WORKS. In 17 Vols Each 6s. 6d.  
 net.  
 I. LORD ARTHUR SAVILE'S CRIME AND

THE PORTRAIT OF MR. W. H. II. THE  
 DUCHESS OF PADUA. III. POEMS. IV.  
 LADY WINDERMERE'S FAN. V. A  
 WOMAN OF NO IMPORTANCE. VI. AN  
 IDEAL HUSBAND. VII. THE IMPORT-  
 TANCE OF BEING EARNEST. VIII. A  
 HOUSE OF POMEGRANATES. IX. IN-  
 TENTIONS. X. DE PROFUNDIS AND  
 PRISON LETTERS. XI. ESSAYS. XII.  
 SALOME, A FLORENTINE TRAGEDY, and  
 LA SAINTE COURTISANE. XIII. A  
 CRITIC IN PALL MALL. XIV. SELECTED  
 PROSE OF OSCAR WILDE. XV. ART and  
 DECORATION. XVI. FOR LOVE OF THE  
 KING. (5s. net.) XVII. VERA, OR THE  
 NIHILISTS.

**Williamson (G. C.)**

THE BOOK OF FAMILIE ROSE. Richly  
 Illustrated. Demy 4to. £8 8s. net.

## PART II. A SELECTION OF SERIES

**The Antiquary's Books**

Each, illustrated, Demy 8vo 10s. 6d. net.

**The Arden Shakespeare**

Edited by W. J. CRAIG and R. H. CASE.  
 Each, wide Demy 8vo. 6s. net.

The Ideal Library Edition, in single  
 plays, each edited with a full Introduction,  
 Textual Notes and a Commentary  
 at the foot of the page. Now complete  
 in 39 Vols.

**Classics of Art**

Edited by J. H. W. LAING. Each, pro-  
 fusely illustrated, wide Royal 8vo. 15s.  
 net to £3 3s. net.

A Library of Art dealing with Great  
 Artists and with branches of Art.

**The Connoisseur's Library**

With numerous Illustrations. Wide  
 Royal 8vo. £1 11s. 6d. net each vol.  
 EUROPEAN ENAMELS. FINE BOOKS.  
 GLASS. GOLDSMITHS' AND SILVER-  
 SMITHS' WORK. IVORIES. JEWELLERY.  
 MINIATURES. MEZZOTINTS. PORCE-  
 LAIN. SEALS. MUSSULMAN PAINTING.  
 (£3 3s. net.) WATCHES. (£2 2s. net.)

**English Life in English Literature**

General Editors: EILEEN POWER,  
 M.A., D.Lit., and A. W. REED, M.A.,  
 D.Lit. Each, Crown 8vo, 6s. net.

A series of source-books for students of  
 history and of literature.

**The Faiths:** VARIETIES OF CHRISTIAN  
 EXPRESSION. Edited by L. P. JACKS,  
 M.A., D.D., LL.D. Each, Crown 8vo,  
 5s. net each volume. The first volumes  
 are: THE ANGLO-CATHOLIC FAITH  
 (T. A. LACEY); MODERNISM IN THE

ENGLISH CHURCH (P. GARDNER); THE  
 FAITH AND PRACTICE OF THE QUAKERS  
 (R. M. JONES); CONGREGATIONALISM  
 (W. B. SELBIE); THE FAITH OF THE  
 ROMAN CHURCH (C. C. MARTINDALE);  
 THE LIFE AND FAITH OF THE BAPTISTS  
 (H. WHEELER ROBINSON); THE PRES-  
 BYTERIAN CHURCHES (JAMES MOFFATT);  
 METHODISM (W. BARDSLEY BRASH);  
 THE EVANGELICAL MOVEMENT IN THE  
 ENGLISH CHURCH (L. ELLIOTT BINNS);  
 THE UNITARIANS (HENRY GOW).

**The Gateway Library**

Fcap. 8vo. 3s. 6d. each volume.

Pocketable Editions of Works by  
 HILAIRE BELLOC, ARNOLD BENNETT,  
 E. F. BENSON, GEORGE A. BIRMINGHAM,  
 MARJORIE BOWEN, G. K. CHESTERTON,  
 A. CLUTTON-BROCK, JOSEPH CONRAD,  
 J. H. CURLE, GEORGE GISSING, GERALD  
 GOULD, KENNETH GRAHAME, A. P.  
 HERBERT, W. H. HUDSON, RUDYARD  
 KIPLING, E. V. KNOX, JACK LONDON,  
 E. V. LUCAS, ROBERT LYND, ROSE  
 MACAULAY, JOHN MASEFIELD, A. A.  
 MILNE, C. E. MONTAGUE, ARTHUR  
 MORRISON, EDEN PHILLPOTTS, MARMA-  
 DUKE PICKTHALL, J. B. PRIESTLEY,  
 CHARLES G. D. ROBERTS, R. L. STEVEN-  
 SON, and OSCAR WILDE.

**A History of England in Seven Volumes**

Edited by Sir CHARLES OMAN, K.B.E.,  
 M.P., M.A., F.S.A. With Maps.  
 Demy 8vo. 12s. 6d. net each volume.  
 ENGLAND BEFORE THE NORMAN CON-  
 QUEST (Sir C. OMAN); ENGLAND UNDER  
 THE NORMANS AND ANGEVINS (H. W. C.

DAVIES); ENGLAND IN THE LATER MIDDLE AGES (K. H. VICKERS); ENGLAND UNDER THE TUDORS (A. D. INNES); ENGLAND UNDER THE STUARTS (G. M. TREVELYAN); ENGLAND UNDER THE HANOVERIANS (Sir C. GRANT ROBERTSON); ENGLAND SINCE WATERLOO (Sir J. A. R. MARRIOTT).

#### The Library of Devotion

Handy editions of the great Devotional books, well edited. *Small Pott 8vo. 3s. net and 3s. 6d. net.*

#### Methuen's Half-Crown Library

*Crown 8vo and Fcap. 8vo.*

#### Methuen's Two-Shilling Library

*Fcap. 8vo.*

Two series of cheap editions of popular books.

*Write for complete lists.*

#### The Wayfarer Series of Books for Travellers

*Crown 8vo. 7s. 6d. net each.* Well illustrated and with maps. The volumes are:—Alsace, Austria, Czechoslovakia, The Dolomites, Egypt, French Vineyards, Hungary, The Loire, Morocco, Portugal, Provence, Pyrenees, The Seine, Spain, Sweden, Switzerland, Unfamiliar Japan, Unknown Tuscany, The West Indies.

#### The Westminster Commentaries

*Demy 8vo. 8s. 6d. net to 16s. net.*

Edited by W. LOCK, D.D., and D. C. SIMPSON, D.D.

The object of these commentaries is primarily to interpret the author's meaning to the present generation, taking the English text in the Revised Version as their basis.

## THE LITTLE GUIDES

*Small Pott 8vo. Illustrated and with Maps*

THE 65 VOLUMES IN THE SERIES ARE:—

BEDFORDSHIRE AND HUNTINGDONSHIRE 4s. net.

BERKSHIRE 4s. net.

BRITTANY 5s. net.

BUCKINGHAMSHIRE 5s. net.

CAMBRIDGE AND COLLEGES 4s. net.

CAMBRIDGESHIRE 4s. net.

CATHEDRAL CITIES OF ENGLAND AND WALES 6s. net.

CHANNEL ISLANDS 5s. net.

CHESHIRE 5s. net.

CORNWALL 4s. net.

CUMBERLAND AND WESTMORLAND 6s. net.

DERBYSHIRE 4s. net.

DEVON 4s. net.

DORSET 6s. net.

DURHAM 6s. net.

ENGLISH LAKES 6s. net.

ESSEX 5s. net.

FLORENCE 6s. net.

FRENCH RIVIERA 6s. net.

GLOUCESTERSHIRE 5s. net.

GRAY'S INN AND LINCOLN'S INN 6s. net.

HAMPSHIRE 4s. net.

HEREFORDSHIRE 4s. 6d. net.

HERTFORDSHIRE 5s. net.

ISLE OF MAN 6s. net.

ISLE OF WIGHT 4s. net.

KENT 6s. net.

LANCASHIRE 6s. net.

LEICESTERSHIRE AND RUTLAND 5s. net.

LINCOLNSHIRE 6s. net.

LONDON 5s. net.

MALVERN COUNTRY 4s. net.

MIDDLESEX 4s. net.

MONMOUTHSHIRE 6s. net.

NORFOLK 5s. net.

NORMANDY 5s. net.

NORTHAMPTONSHIRE 4s. net.

NORTHUMBERLAND 7s. 6d. net.

NORTH WALES 6s. net.

NOTTINGHAMSHIRE 6s. net.

OXFORD AND COLLEGES 4s. net.

OXFORDSHIRE 4s. net.

PARIS 5s. net.

ROME 5s. net.

ST. PAUL'S CATHEDRAL 4s. net.

SHAKESPEARE'S COUNTRY 4s. net.

SHROPSHIRE 5s. net.

SICILY 4s. net.

SNOWDONIA 6s. net.

SOMERSET 4s. net.

SOUTH WALES 4s. net.

STAFFORDSHIRE 5s. net.

SUFFOLK 4s. net.

SURREY 5s. net.

SUSSEX 5s. net.

TEMPLE 4s. net.

VENICE 6s. net.

WARWICKSHIRE 5s. net.

WESTMINSTER ABBEY 5s. net.

WILTSHIRE 6s. net.

WORCESTERSHIRE 6s. net.

YORKSHIRE EAST RIDING 5s. net.

YORKSHIRE NORTH RIDING 4s. net.

YORKSHIRE WEST RIDING 7s. 6d. net.

YORK 6s. net.

METHUEN & CO. LTD., 36 ESSEX STREET, LONDON, W.C.2.







